

THE LOWER PALAEOZOIC BRACHIOPOD AND  
TRILOBITE FAUNAS OF ANGLESEY



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# THE LOWER PALAEOZOIC BRACHIOPOD AND TRILOBITE FAUNAS OF ANGLESEY

By D. E. B. BATES

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## SYNOPSIS

Arenig sandstones, grits and conglomerates rest unconformably on pre-Cambrian rocks and contain a shelly fauna with Baltic affinities, predominantly of brachiopods and trilobites. New brachiopods include *Ahtiella quadrata* sp. nov., *Hesperonomiella carmelensis* sp. nov., *Monorthis typis* gen. et sp. nov., *Panderina lamellosa* sp. nov., *Rectotrophia globularis* gen. et sp. nov., *Reinversella monensis* gen. et sp. nov., *Rhynchorthis rotundus* gen. et sp. nov. and *Pleurorthis costatus* sp. nov. A new trilobite, *Monella perplexa* gen. et sp. nov. is also present.

Higher Arenig and Llanvirn shales, grits, conglomerates, shaley breccias and ironstones contain mixed graptolitic and shelly faunas, including one new brachiopod, *Ahtiella concava*.

Lower Caradoc rocks resting unconformably on older Ordovician or pre-Cambrian rocks comprise conglomerates and breccias with shelly faunas, and ironstones and graptolitic shales. A brachiopod-graptolite fauna from Llanbabo and Caregonen can be correlated with the Derfel Limestone fauna of the Arenig district. Limestone blocks in a breccia of the same age yielded a brachiopod-trilobite fauna, including *Protobronteus greenlyi* sp. nov.

Graptolitic shales of Llandovery age at Parys Mountain rest on an acid volcanic group of Caradoc(?) age.

## I. INTRODUCTION AND ACKNOWLEDGMENTS

ALTHOUGH Anglesey attracted the attention of several workers in the nineteenth century, our knowledge of the Ordovician stratigraphy is due mainly to the Geological Survey Memoir of Greenly (1919), in which use was made of the standard graptolitic zoning developed by Lapworth, Elles and Wood to date the rocks. The

shelly faunas are under-represented in his collections; in particular the important Caradoc fauna from Llanbabo is not represented at all, though a large graptolite fauna is listed from the same locality (Greenly 1919 : 455).

The Ordovician fossils have not been the subject of any intensive study since Greenly's time, or indeed before it. Few species or genera have been erected from among them, and identification has been made in most cases by geologists who were not working on the island. Since the publication of Greenly's memoir two papers have contained accounts of some of the fossils from his collection.

Shirley (1936) in his account of the British Calymenidae referred the calymenids collected by Greenly from the basal beds of the Principal Area to the new species *Synhomalonotus monensis* (now *Neseuretus monensis*), and Whittard (1956 : 17) commented on a specimen of *Ampyx* from the collection. The writer has already described a new species of gastropod, *Matherella(?) acuticostata*, from the Arenig Treiorwerth Formation (1963).

I wish to thank Professor A. Williams for his guidance throughout this work, and for his critical reading of the text. The following have commented on specific aspects of the palaeontology: the late Dr. L. R. Cox, Professor C. Poulsen, Professor G. Regnéll, Dr. I. Strachan, Mr. R. P. Tripp, Professor H. B. Whittington and Professor A. Wood.

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I am grateful for the help given to me by many friends, including staff and students of the University College of Wales, for their aid in collecting specimens, and for discussions in the field and laboratory.

## II. SYNOPSIS OF STRATIGRAPHY

The Ordovician rocks of Anglesey crop out in a number of areas, separated principally by upfaulted blocks of the Mona Complex. In general precise lithological correlations cannot be made between them, although two suites of arenaceous and rudaceous rocks are widespread, one of Arenig age and the other Caradocian.

### (a) *Eastern Anglesey*

On the Menai Straits basal conglomerates and grits (the Garth Ferry Grits) rest on the Mona Complex at Garth Ferry, near Beaumaris, and are overlain by shales with *Ptilograptus*. The age of the succession is not known with precision, but since the *Didymograptus extensus* zone is present on the Caernarvonshire shore of the straits between the bridges (Greenly 1919 : 431) the Garth Ferry rocks are probably of approximately the same age.

The area around Llangoed is poorly exposed, but a shelly fauna was collected from grey shales (the Tandinas Shales) at Caregonen. The shales are uncleaved and very soft, grey in colour, with plentiful mica flakes parallel to the bedding. The succession is complicated by north-dipping thrusts, though the shales appear to be dipping at low angles. Greenly found the faunas collected from them per-





plexing (1919 : 433), as they appeared to be of widely different horizons. This was due to Lake's identification of *Ampyx nasutus* Dalman from the shales, a form known to him only from the *Didymograptus bifidus* zone in South Wales, while the graptolites found were typical of the *Nemagraptus gracilis* Zone. The *Ampyx* is however, possibly a new species, while the associated brachiopods are conspecific with those from the Derfel Limestone of the Bala district (Whittington & Williams 1955).

The fauna is: *Climacograptus antiquus* Lapworth (?), *Cl. scharenbergi* Lapworth, *Climacograptus* sp., *Nicolella* sp., *Platystrophia* sp., *Leptestiina derfelensis* (Jones), *Sericoidaea abdita* Williams, dalmanellid brachiopod, ogygiid trilobite, *Ampyx* sp. (2), *Sphaerexochus* sp., *Amphilichas* sp. (2), lamellibranch, *Echinosphaerites* sp.

(b) *The Berw Fault Complex*

Ordovician rocks (the Berw Group) incorporated in the Berw Fault complex, crop out at intervals from Pentraeth, at the head of Red Wharf Bay, to Tai Hirion, south-west of Holland Arms, a lower arenaceous division being succeeded by blue shales.

Berw Group	}	Glanmorfa Shales	Blue shales	?
		Dryll Formation	Greywackes with interbedded shales	300 ft.
		Berw-Uchaf Grits	Quartz grits and sandstones	60-100 ft.

North-east of Holland Arms the basal rocks are poorly exposed, but at Bwlch Gwyn a small exposure of sandstone and shale appears to rest on a pre-Ordovician felsite (Greenly 1919 : 435), though the junction is probably faulted. The sandstone has yielded: *Lenorthis proava* (Salter), *Skenidioides* sp., *Rhynchorthis rotundus* gen. et sp. nov., *Estlandia* (?) sp.

The same horizon is exposed in Rhyd-yr-arian ravine, where the stream is crossed by the road; the following list is from the collections of Greenly and the writer: *Didymograptus hirundo* Salter, *Lenorthis proava* (Salter), *Pleurorthis*(?) sp., *Rhynchorthis rotundus* gen. et sp. nov., *Monorthis*(?) sp., *Reinversella monensis* gen. et sp. nov., *Rectotrophia*(?) sp., *Antigonambonites*(?) sp., polyzoan, crinoid ossicles.

(c) *The Llangwyllog Area*

The faulted outlier around Llangwyllog is also poorly exposed; though no shelly fossils have been found the succession commences with an arenaceous division which is at youngest Llanvirn (Greenly 1919 : 437). Higher shales are Caradoc in age, and an ironstone is present (the Ty'n-yr-onen Ironstone).

(d) *The Principal Area*

In the Principal Area the succession is more complete than elsewhere. The basal arenaceous beds of conglomerate, grit and current-bedded sandstone (the

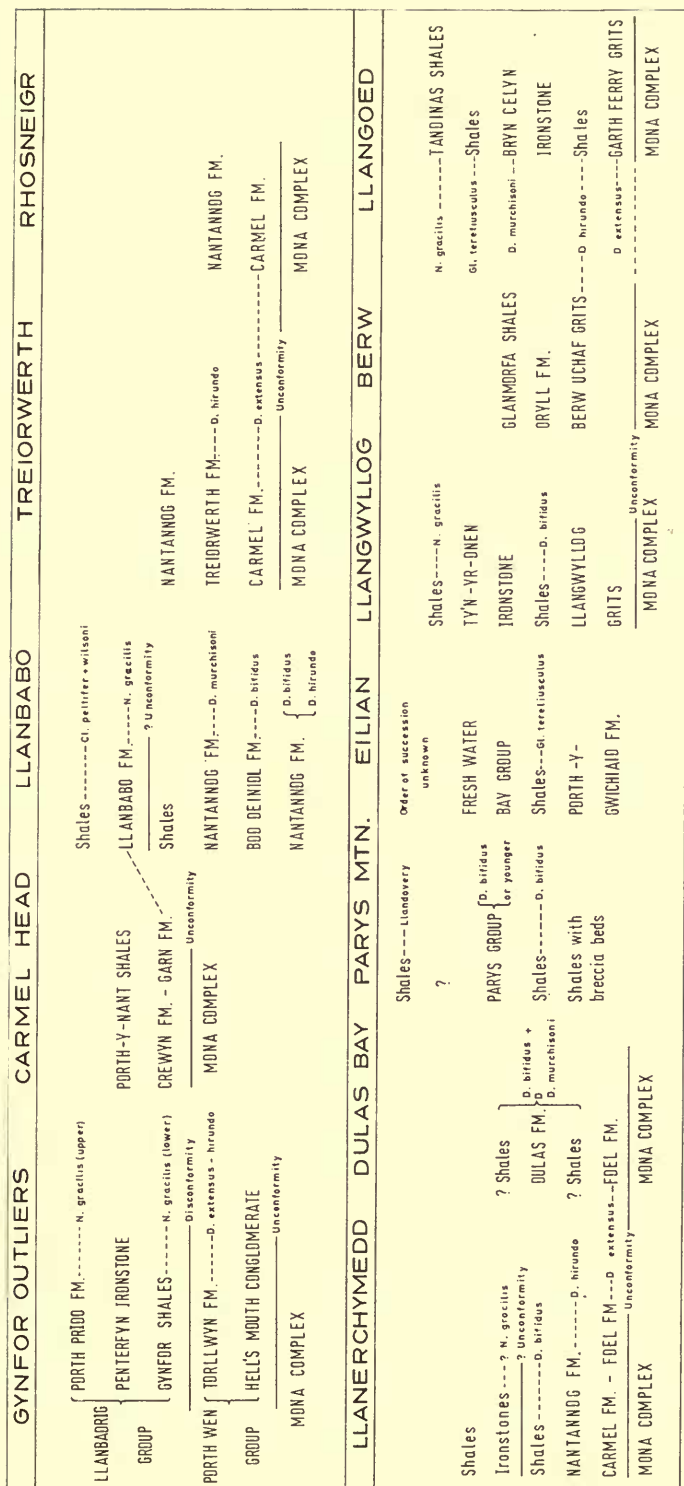


FIG. 2.

Carmel Formation, the Foel Formation) crop out mainly along the south-east boundary lying unconformably on the Mona Complex. The Carmel Formation is exposed from Rhosneigr to within a mile of Llanerchymedd, and comprises a lower fossiliferous division of sandstones and conglomerates, and an upper sparsely fossiliferous division with current bedding. The chief fossiliferous localities are:

- (i) by the roadside one-eighth of a mile north-west of Ty-hen (Greenly 1919 : 442). *Lenorthis proava* (Salter), *Hesperonomiella carmelensis* sp. nov., *Neseuretus monensis* (Shirley), *Ogygiocaris selwynii* (Salter), *Monella perplexa* gen. et sp. nov.
- (ii) in the scarp above Prys-owain-bach cottage, Carmel. *L. proava*, *H. carmelensis*, *M. perplexa*.
- (iii) small quarry pit 100 yds. north-west of Chaen-bach. *Ogygiocaris* sp., *N. monensis*.

The type material of *Monella perplexa* comes from an old quarry, now filled in, 400 yds. north of Bryn Gollen Uchaf, half a mile west of Llanerchymedd.

The Foel Formation is at least a partial lateral equivalent of the Carmel Formation, and only occurs east of Llanerchymedd. It consists of conglomerates succeeded by flaggy sandstones with shale partings, but has so far proved unfossiliferous.

Above the basal rocks are five variable rudaceous and arenaceous formations ranging in age from the *D. extensus* zone to the *D. bifidus* zone; they pass laterally and vertically into poorly exposed shales which contain faunas from the *D. murchisoni* zone.

The Treiorwerth Formation is a thick series of sandstones, grits and conglomerates derived from Mona Complex schists and jaspers, exposed between Rhosneigr and Treiorwerth, and resting on the Carmel Formation. South-east of Ffynnon-y-mab, Trefor, the lowest horizons consist of grey-green siltstones with coarse micaceous shale partings, which pass up through 350 ft. of siltstones and sandstones to coarse grits and conglomerates which are typical of the formation. Three hundred yards south-east of Ffynnon-y-mab (Greenly 1919 : 442) graptolite fragments in the sandstones were identified by Elles as ?*Tetraraptus headi* (Hall). Sandstones in the same outcrop have a rich fauna, occurring as water-sorted lenticles of disarticulated valves: *Lenorthis proava* (Salter), *Monorthis typis* gen. et sp. nov., *Pleurorthis costatus* sp. nov., *Panderina lamellosa* sp. nov., *Hesperonomiella*(?) sp., *Skenidioides* sp. (1), *Rhynchorthis rotundus* gen. et sp. nov., *Reinversella monensis* gen. et sp. nov., *Rectotrophia globularis* gen. et sp. nov., *Porambonites* (s.s.) sp., *Tritoechia* sp., *Antigonambonites pyramidalis* sp. nov., *Matherella*(?) *acuticostata* Bates, *Monella*(?) sp., polyzoan fragments, crinoid ossicles.

The Nantannog Formation is a thick sequence of shales, with a variable rudaceous content, mainly as scattered pebbles and slabs of phyllite, but sufficiently concentrated at certain horizons to produce grits and conglomerates with a shaley matrix. The lithology persisted from the *D. extensus* to the *D. murchisoni* zones, and some of the lower horizons contain brachiopods of the Nantannog Formation fauna. A fauna indicative of the *D. bifidus* zone was found by Greenly at two localities,



on the same strike. From the first, west of the road at the bend 200 yards west of Fferam-uchaf farm, Llanbabo, Greenly's specimens were re-examined, no more having been found: *D. bifidus* (Hall), *D. hirundo* Salter, *Orthambonites* (?) sp. (1).

A shelly fauna was found at the second locality, 190 yards south-east of the farm: *D. bifidus* (Hall)(?), *D. hirundo* Salter(?), *Lingula* sp., *Orthambonites*(?) sp., *Skenidioides* sp. (2), *Ptychopleurella* sp., *Dactylogonia* sp., polyzoan fragments, crinoid ossicles.

Two hundred and fifty yards west-south-west of Fferam uchaf Greenly (1919 : 452) found *D. murchisoni* (Beck), and his collection also contains: orthid brachiopod, illaenid pygidium, *Bergamia*(?) sp., *Placoparia* sp., *Cyclopyge*(?) sp.

Laterally and vertically the Nantannog Formation passes into shales or the Treiorwerth Formation, except at Bod Deiniol, south of Llanbabo, where it is succeeded by a thick succession of conglomerates, pebbly grits and sandstones, the Bod Deiniol Formation. The most prominent member is a conglomerate, 80 ft. thick, which occurs near the base of the formation and forms a scarp south of Bod Deiniol. The formation probably belongs to the *D. bifidus* zone, as Greenly records graptolites from low in the zone at Bodynolwyn-hir (1919 : 444) in beds underlying the grits, and beds about 100 ft. above the conglomerate member exposed in the bed of the River Alaw have yielded a pendent *Didymograptus*. The formation loses its topographic expression to the south-east towards Ty-bach cottage, and the grain size becomes finer, although the conglomerate may here be concealed by drift. Fifty yards north of the cottage the writer succeeded in obtaining a fauna from massive grits—probably from a horizon above the conglomerate—when a trench was being excavated in connection with the building of the Alaw reservoir: *Lenorthis* sp., *Panderina*(?) sp., *Paurorthis*(?) sp., *Apomatella*(?) sp., *Ahtiella concava* sp. nov.

North of Dulas Bay a succession of alternating sandstones and shales, the Dulas Formation, with worm burrowing, cone-in-cone concretions, neptunian dykes and current bedding, is well exposed on the shore and poorly inland. On the shore it is faulted against shales containing *D. bifidus* and *D. murchisoni* zone faunas.

Over much of the Principal Area shales are poorly exposed, and Greenly records both lower Ordovician and Caradoc faunas from a number of localities; no formal stratigraphic name is however proposed for them. One new locality, 100 yards north of Gwredog-uchaf, Rhodogeidio, has a graptolite-trilobite fauna: *Dictyonema* sp., *D. bifidus* (Hall), *D. artus* Elles & Wood, *D. stabilis* Elles & Wood, *Climacograptus* cf. *scharenbergi* Lapworth, *Climacograptus* sp., *Glossograptus hincksii fimbriatus* (Hopkinson), *Bergamia*(?) sp.

At Parys Mountain a volcanic suite (the Parys Group) rests on shales (the Parys Shales) of the *D. bifidus* zone or later: graptolites have been found in tips from shafts sunk beneath the volcanic rocks at the west end of the mountain (Greenly 1919 : 458). Although Greenly described the shales immediately beneath and to the north of the igneous rocks as Hartfell in age there is no palaeontological evidence for this. The igneous suite, described by Greenly as a felsite sill, is a complex of rhyolites, autobreccias, ignimbrites, tuffs and shales, intensively cleaved, sheared and silicified (Hawkins 1966 : 13). Above the Parys Group, in the core of the syn-

cline, is a succession of shales and mudstones of Silurian age whose relation to the older rocks is unknown.

Llandeilo fossils (Greenly 1919 : 465) have been found associated with an ironstone at Bônw, and also in a borehole at Llangoed (Greenly 1919 : 432). The extent and thickness of Llandeilo rocks is, however, unknown.

Caradoc rocks are well exposed in the north-west of the Principal Area, where a variable group of basal rudaceous rocks overlies the Mona Complex. On Mynydd-y-garn and at Porth Padrig, north of Mynachdy, on both sides of the Carmel Head thrust a thick series of breccias, overlain by shales and alternating breccia beds (the Garn Formation), rests on several horizons in the Complex. The breccia contains slabs of schists and phyllites up to several feet long, and also rounded blocks of shelly limestone; at Porth Padrig, Greenly records a graptolite fauna from the *N. gracilis* zone in the shales, and the blocks have yielded: *Cyrtonotella* sp. (2), *Palaeostrophomena*(?) sp., *Ptychoglyptus* sp., *Kiaeromena*(?) sp., *Camerella* sp., *Metacamerella* cf. *balcletchiensis* (Davidson), *Protobronteus greenlyi* sp. nov., *Iliaenus* sp., *Stenopareia* sp., *Selenoharpes*(?) sp., *Pliomerops* sp.

On Pen-bryn-y-eglwys, and on the coast to the south, the Mona Complex is overlain by a sandy and gritty formation, the Crewyn Formation, which varies in thickness between 60–150 ft. About 2 ft. above the unconformity, 300 yds. east of Trwyn y Crewyn poorly-preserved shells were found: *Orthambonites* sp., *Plaesiomyys* sp., *Platystrophia*(?) sp., lamellibranch, crinoid ossicles.

West of Mynachdy, around an old barn called Ysgubor-gader, is a complicated region of folded and faulted shales, grits and pre-Cambrian rocks. Two small exposures of grit, apparently resting on the pre-Cambrian, are poorly exposed 225 yds. south-west and 400 yds. west-south-west of the barn, and contain *Plaesiomyys* cf. *robusta* (Bancroft), *Orthambonites*(?) sp. *Dalmanella* (s.l.) sp. and a cystid plate.

In the Llanbabo region Caradoc rocks either rest on or are faulted against gritty beds of the *D. murchisoni* zone, but the contact is not exposed (Greenly 1919 : 451–456). The most complete section is seen at Fferam-uchaf where the rocks strike east-west through the farmyard:

Llanbabo Formation	{ { {	Llanbabo Church Grits	Pebbly grits alternating with shales	20 ft. +
		Fferam Shales	Dark Blue shales	60 ft.
		Fferam Ironstone	Ironstone and ferri-ferous grit	20–40 ft.

The ironstone and succeeding shales are also exposed in an old quarry south of Llanbabo (Greenly 1919 : 543), and graptolites of the *N. gracilis* zone were obtained from the shales in both areas by Greenly and his collectors.

The Llanbabo Church Grits are best exposed in the old quarry 100 yds. south-west of the church, where 20 ft. of strata are exposed, pebbly graded grit beds up to 2 ft. thick alternating with silty blue-grey shales. The latter contain a graptolite fauna, regarded by Elles (in Greenly 1919 : 455) as being high in the *N. gracilis* zone, above the Fferam Shales. The grits contain a shelly fauna, mainly of dis-

articulated brachiopod valves, which correlates well with the Tandinas Shales at Careg-onen, and with the Derfel Limestone of the Arenig area (Whittington & Williams, 1955): *Orthambonites* (?) sp. (2), *Nicolella humilis* Williams, *Cyrtonotella* sp. (1), *Dolerorthis* cf. *tenuicostata* Williams, *Platystrophia precedens major* Williams, *Ptychopleurella* sp. (2), *Plaesiomys* (*Dinorthis*) sp., *Salopia salteri gracilis* Williams, *Onniella*(?) sp., *Orderleyella*(?) sp., *Kullervo* aff. *panderi* Öpik, *Clitambonites*(?) sp., *Ilmarinia* sp., *Palaeostrophomena* sp., *Eoplectodonta lenis* Williams, *Leptaena*(?) sp., *Echinosphaerites* sp.

The Llanbabo Church Grits are also exposed at Fferam-uchaf, in the north-east corner of the field immediately east of the farmhouse (Greenly 1919 : 451 and outcrop labelled 'conglm.' in fig. 207), with a similar fauna: *Orthambonites* (?) sp., *Platystrophia*(?) sp., *Ptychopleurella* sp. (2), *Plaesiomys* sp., *Dolerorthis*(?) sp., *Salopia*(?) sp., *Bilobia* aff. *musca* Öpik, *Leptestiina* sp., *Eoplectodonta lenis* Williams, *Leptaena* sp.

Above the basal Caradoc rocks of the *N. gracilis* zone are shales, poorly exposed and of uncertain extent. Greenly (1919 : 454-455) records graptolites from the zones of *Cl. wilsoni* and *Dicranograptus clingani*, from shales at Llanbabo which probably rest on the Llanbabo Church Grits. There is no evidence of the thickness of these zones, or of their relation one to another, though the close proximity of the outcrops to the older Caradocian rocks suggests that the zones are not very thick.

In the Eilian sector no fossils have been found to add to Greenly's collection (1919 : 466), which contains *Glyptograptus teretiusculus* (Hisinger) and *Placoparia* sp. The section seen on the shore between the Carmel Head Thrust at Porth-y-corwgl and the gneisses south of Porth-y-gwichiaid contains a number of units, separated by faults. Between Porth-y-corwgl and Fresh Water Bay are a series of conglomerates, pebbly grits and shales (the Fresh Water Bay Group), all apparently younging south and overturned. Between Ogof Fach and Ogof Fawr are highly cleaved and sheared grey shales, intruded by acid sills. On the northern side of Porth-y-gwichiaid are fine siltstones and mudstones, with some worm burrows, also cleaved and folded; it is not known in which direction they young. On the south side of the Porth is a series of siltstones, shales, conglomerates and an ironstone, partly slumped in some horizons, and disposed in a complex syncline.

#### (e) *The Gynfor Outliers*

On the north coast the Ordovician rocks are exposed in a number of faulted and folded outliers resting on the Mona Complex. Two groups are present, separated by a disconformity. The earlier (Porth Wen Group), of Arenig Age, is of two conglomerate and grit formations, the lower being a purple conglomerate (the Hell's Mouth Conglomerate), absent from some exposures, and the upper a pale brown weathering sequence of conglomerates, grits and sandstones containing an Arenig fauna (the Torllwyn Formation). Brachiopods were obtained from some of the localities listed by Greenly (1919 : 469-470):

- (i) 10 ft. above the unconformity on the north side of Ogof Gynfor (exposure



in Greenly *op. cit.*, Pl. XXIX): *Rhynchorthis rotundus* gen. et sp. nov., *Estlandia*(?) sp.

- (ii) about 40 ft. above the unconformity, 45 yds. north of the last locality, north of the faulted syncline containing Gynfor Shales in the core: *Lenorthis* sp., *Hesperonomiella*(?) sp., *Monorthis* sp., *Panderina* cf. *lamellosa* sp. nov., *Pleurorthis* sp., *Skenidioides* sp., *Rhynchorthis* sp., *Tritoechia* sp., *Antigonambonites* sp., *Inversella* (*Reinversella*?) sp., *Ahtiella quadrata* sp. nov., crinoid ossicles, polyzoan fragments.
- (iii) Thirty to forty ft. above the unconformity, on the north side of the ridge of Mynydd-pant-y-gaseg, 85 ft. east of the summit: *Orthambonites*(?) sp., *Ahtiella*(?) sp. (poorly preserved).
- (iv) in the cutting of the Graig Wen tramway, 70 yds. below the winding house, collected from loose material: *Lenorthis* cf. *proava* (Salter), *Panderina*(?) sp., *Rhynchorthis*(?) sp., *Antigonambonites*(?) sp.

The specimens of *Lenorthis* examined include a number from the Geological Survey collection (Z1470-1502).

The upper group (Llanbadrig Group) is Caradoc in age, with an ascending sequence of cherty shales (Gynfor Shales), an ironstone (Penterfyn Ironstone) and shales and ferriferous grits (Porth Pridd Formation). Faunas of graptolites from the lower and upper formations (Greenly 1919: 470-471) come from the *N. gracilis* zone, and hence (it is unlikely that the Arenig fossils are derived) there must be a plane of disconformity within the Torllwyn Formation or at its top. Erosion surfaces are present within it, and the contact with the shales above is also abrupt, with the shales resting on a slightly irregular surface of coarse conglomerate.

The Silurian shales of Parys Mountain lie above the volcanic Parys Group but the nature of the contact between them is unknown. Greenly (1919: 481-482) lists graptolite faunas from all the Llandoverly zones. There is no palaeontological evidence for Silurian rocks at Rhos-mynach (Greenly 1919: 482-483), and the shales there are intercalated between rhyolites which are probably equivalent to the Parys Group.

#### (f) Faunal Lists

Explanation of symbols: ex. = *Didymograptus extensus* Zone; hi. = *D. hirundo* Zone; bi. = *D. bifidus* Zone; mu. = *D. murchisoni* Zone; te. = *Glyptograptus teretiusculus* Zone; gr. = *Nemagraptus gracilis* Zone.

#### BRACHIOPODA

	ex.	hi.	bi.	mu.	te.	gr.
<i>Ahtiella concava</i> sp. nov.	—	—	×	—	—	—
<i>Ahtiella quadrata</i> sp. nov.	—	×	—	—	—	—
<i>Antigonambonites pyramidalis</i> sp. nov.	—	×	—	—	—	—
<i>Apomatella</i> (?) sp.	—	—	×	—	—	—
<i>Bilobia</i> aff. <i>musca</i> (Öpik)	—	—	—	—	—	×
<i>Camerella</i> sp.	—	—	—	—	—	×?
<i>Clitambonites</i> (?) sp.	—	—	—	—	—	×
<i>Cyrtonotella</i> sp. (1)	—	—	—	—	—	×

	ex.	hi.	bi.	mu.	te.	gr.
<i>Cyrtototella</i> sp. (2)	—	—	—	—	—	×?
<i>Dactylogonia</i> sp.	—	—	×	—	—	—
<i>Dalmanella</i> (?) sp.	—	—	—	—	—	×
<i>Dolerorthis</i> cf. <i>tennicostata</i> Williams	—	—	—	—	—	×
<i>Eoplectodonta lenis</i> Williams	—	—	—	—	—	×
<i>Estlandia</i> (?) sp.	—	×	—	—	—	—
<i>Harknessella</i> (?) sp.	—	—	—	—	—	×
<i>Hesperonomiella carmelensis</i> sp. nov.	×	×?	—	—	—	—
<i>Hordeleyella</i> (?) sp.	—	—	—	—	—	×
<i>Ilmarinia</i> sp.	—	—	—	—	—	×
<i>Kiaeromena</i> (?) sp.	—	—	—	—	—	×?
<i>Kullervo</i> aff. <i>panderi</i> (Öpik)	—	—	—	—	—	×
<i>Lenorthis proava</i> (Salter)	×	×	—	—	—	—
<i>Lenorthis</i> sp.	—	—	×	—	—	—
<i>Leptaena</i> sp.	—	—	—	—	—	×
<i>Leptestiina derfelensis</i> (Jones)	—	—	—	—	—	×
<i>Metacamarella</i> cf. <i>balclatchiensis</i> (Davidson)	—	—	—	—	—	×?
<i>Monorthis typis</i> gen. et sp. nov.	—	×	—	—	—	—
<i>Nicolella humilis</i> Williams	—	—	—	—	—	×
<i>Onniella</i> (?) sp.	—	—	—	—	—	×
<i>Orthambonites</i> (?) sp. (1)	—	—	×	—	—	—
<i>Orthambonites</i> (?) sp. (2)	—	—	—	—	—	×
<i>Palaeostrophomena</i> sp.	—	—	—	—	—	×
<i>Palaeostrophomena</i> (?) sp.	—	—	—	—	—	×?
<i>Panderina lamellosa</i> sp. nov.	—	×	×?	—	—	—
<i>Paurorthis</i> (?) sp.	—	—	×	—	—	—
<i>Plaesiomys</i> sp.	—	—	—	—	—	×
<i>Plaesiomys</i> cf. <i>robusta</i> (Bancroft)	—	—	—	—	—	×
<i>Plaesiomys</i> ( <i>Dinorthis</i> ) sp.	—	—	—	—	—	×
<i>Platystrophia precedens major</i> Williams	—	—	—	—	—	×
<i>Plectorthis</i> (?) sp.	—	—	×	—	—	—
<i>Pleurorthis costatus</i> sp. nov.	—	×	—	—	—	—
<i>Porambonites</i> (s.s.) sp.	—	×	—	—	—	—
<i>Ptychoglyptus</i> sp.	—	—	—	—	—	×?
<i>Ptychopleurella</i> sp. (1)	—	—	×	—	—	—
<i>Ptychopleurella</i> sp. (2)	—	—	—	—	—	×
<i>Rectotrophia globularis</i> gen. et sp. nov.	—	×	—	—	—	—
<i>Reinversella monensis</i> gen. et sp. nov.	—	×	—	—	—	—
<i>Rhynchorthis rotundus</i> gen. et sp. nov.	—	×	×	—	—	—
<i>Salopia salteri gracilis</i> Williams	—	—	—	—	—	×
<i>Sericoidea abdita</i> Williams	—	—	—	—	—	×
<i>Skenidioides</i> sp. (1)	—	×	—	—	—	—
<i>Skenidioides</i> sp. (2)	—	—	×	—	—	—
<i>Tritoechia</i> sp.	—	×	—	—	—	—

## TRILOBITA

<i>Amphilichas</i> sp. (1)	—	—	—	—	—	×
<i>Amphilichas</i> sp. (2)	—	—	—	—	—	×
<i>Ampyx</i> sp. (1)	×	—	—	—	—	—
<i>Ampyx</i> sp. (2)	—	—	—	—	—	×
<i>Bergamia</i> (?) sp.	—	—	×	—	—	—
Calymenid	—	—	—	—	—	×?

	ex.	hi.	bi.	mu.	te.	gr.
<i>Ceraurinnella</i> sp. . . . .	—	—	—	—	—	×?
<i>Illaenus</i> sp. . . . .	—	—	—	—	—	×?
<i>Monella perplexa</i> gen. et sp. nov. . . . .	×	×?	—	—	—	—
<i>Neseuretus monensis</i> (Shirley) . . . . .	×	—	—	—	—	—
<i>Ogygiocaris selwynii</i> (Salter) . . . . .	×	—	—	—	—	—
<i>Placoparia</i> sp. . . . .	—	—	—	—	×?	—
<i>Pliomerops</i> sp. . . . .	—	—	—	—	—	×?
<i>Protobrontzus greenlyi</i> sp. nov. . . . .	—	—	—	—	—	×?
<i>Selenoharpes</i> (?) sp. . . . .	—	—	—	—	—	×?
<i>Sphaerexochus</i> sp. . . . .	—	—	—	—	—	×
<i>Stenopareia</i> sp. . . . .	—	—	—	—	—	×?

### III. FAUNAL AFFINITIES AND CORRELATIONS

The basal rocks of the Principal Area, the Carmel Formation, have a fauna characterized by few species, but a large number of individuals, especially *Lenorthis proava* (Salter), which occurs in vast numbers as disarticulated valves. Similar species are found elsewhere in Wales at this horizon, at Arenig in the Henllan Ash, and at St. David's and the Carmarthen-Whitland region. In the latter regions they are described as *Orthis carausii* Salter, and are associated with *Lenorthis alata* (Salter). *Ogygiocaris selwynii* (Salter) and *Neseuretus monensis* (Shirley), which are found sporadically, belong to genera which are widespread throughout Wales at this time. *Monella perplexa* gen. et sp. nov. is at present cryptogenic, but may be a survivor of the Cambrian *Corynexochida*.

*Hesperonomiella carmelensis* sp. nov. belongs to a genus described by Ulrich & Cooper (1938) from the upper Canadian (approximately upper Llanvirn) of much of North America. The genus is described as having chilidial plates, but in some cases they are very rudimentarily developed, and in this species are not developed at all. It is possible that later species of *Hesperonomiella* and its ally *Hesperonomia* have their origin in forms comparable with this species.

Near the base of the overlying Treiorwerth Formation, and at the base of the system along the Berw Fault is a rich shelly fauna, consisting almost wholly of brachiopods. Three stocks, *Lenorthis proava*, *Hesperonomiella carmelensis*, and *Monella*(?) sp. persist from the Carmel Formation, but are joined by a variety of forms, some new, some with American affinities, and some very similar to contemporary Baltic faunas. *Rhynchorthis rotundus* gen. et sp. nov., *Porambonites* sp. and *Antigonambonites pyramidalis* sp. nov. are closely related to contemporary Baltic stocks (Alichova 1953, Table 1). *Porambonites* and *Antigonambonites* appear similar in morphological grade to the earliest Russian species (of B<sub>1</sub>β in Estonia, o<sub>1</sub>v<sub>1</sub> on the Russian platform) and one can correlate the Anglesey fauna with confidence with this horizon. *Rhynchorthis* is similar to *Angusticardinia*, also from this level, but appears to be more primitive in its features. *Panderina lamellosa* is more advanced than contemporary Russian species, again from this horizon. *Reinversella monensis* gen. et sp. nov. is closely related to *Inversella* Öpik from Estonia and Norway, a later genus from the upper Arenig (B<sub>111</sub> and later) (Öpik 1933 : 23). *Ahtiella quadrata* sp. nov., is a member of a genus which is also found

later in the Baltic region (B<sub>111</sub>-C<sub>1</sub>). It is thus probable that the two faunas were closely linked at this time with migration possible in either direction.

The stocks with American affinities, *Pleurorthis costatus* sp. nov. and *Tritoechia* sp., differ markedly from those just described. In America *Pleurorthis* is known from the much later Mystic conglomerate of Quebec and the Table Head Series of Newfoundland (both upper Llanvirn), with rather different species (Cooper 1956 : 330-333). *Tritoechia* ranges throughout the Arenig equivalents in North America (much of the Canadian of Twenhofel *et al.*, 1954, chart 2).

*Monorthis typis* gen. et sp. nov. is of uncertain affinities, and makes its only known appearance in this fauna. *Skenidioides* can probably best be regarded as indigenous, as it occurs in the Mytton Flags of Shropshire and at Tourmakeady, Co. Mayo (Professor A. Williams, personal communication), and is also present in the Whitland region. *Rectotrophia globularis* gen. et sp. nov. has affinities with both American and Bohemian forms. *Matherella*, a sinistral gastropod, belongs to a small but widespread group of shells, with both American and Bohemian members.

Llanvirn shelly faunas are sparse, as the sediments are predominantly shaley. *Orthambonites*(?) sp. (1) may be regarded as indigenous, being closely related to *Lenorthis*, as may *Skenidioides* sp. (2) descended from the Arenig species. *Ahtiella concava* sp. nov. either is descended from the Arenig species, or is a later migrant from the Baltic region. *Ptychopleurella* sp. (1) is an atypical member of the genus, possibly earlier than any of the American species. Trinucleids make their appearance in Anglesey at this time, but are indigenous south British elements which have been recorded widely within Wales (Whittard 1955-64; Whittington 1966), and may well have reached Anglesey earlier than this time.

The dominant shelly fauna taken from rocks belonging to the *Nemagraptus gracilis* Zone is closely comparable with that found at Derfel, near Arenig (the Derfel Limestone fauna of Whittington & Williams 1955), which has been divided into a native association of elements known in Wales from older rocks, together with stocks which migrated from the east Baltic, Russia, Bohemia and the North Atlantic Province. As developed in Anglesey the fauna has similar elements. Native stocks include *Orthambonites* (?) sp. (2), *Ptychopleurella* sp. (2), *Dinorthis* sp., *Eoplectodonta lenis* Williams, *Sericoidea abdita* Williams, *Salopia salteri gracilis* Williams, *Onniella*(?) sp., *Horderleyella* sp., *Amphilichas* sp. (2), *Ampyx* sp. (2), and trinucleids. Elements regarded by Whittington & Williams as exotic include *Nicolella humilis* Williams, *Cyrtotonella* sp., *Dolerorthis* cf. *tenuicostata* Williams, *Platystrophia precedens major* Williams, *Palaeostrophomena* sp., *Leptaena* sp., *Leptetiina derfelensis* (Jones) and *Kullervo* aff. *panderi* Öpik. Other stocks occurring in Anglesey, but not so far found at Derfel, provide further evidence of the Baltic affinities of the fauna. *Bilobia* aff. *musca* Öpik has strong affinities with Öpik's species, from this horizon in the east Baltic. *Ilmarinia* sp. and *Clitambonites*(?) sp. also belong to Baltic genera, though *Ilmarinia* occurs at a higher horizon in the east. In the light of the affinities of the Arenig faunas discussed above, the Derfel Limestone fauna is best regarded, not as an invasion of the region by an entirely new fauna during the *N. gracilis* transgression, but as the continuation of an association which existed in the lower Ordovician.



The fauna of the limestone blocks in the Garn Breccia at Porth Padrig is not younger than the *N. gracilis* Zone, and may be older. The trilobites of the limestone are similar to those of the Derfel Limestone, *Ceraurinella*, *Amphilichas* and *Illaenus* being common to both. Other trilobites in the fauna are *Selenoharpes*(?) sp., a calymenid, *Piomeroops* sp. and *Protobronteus greenlyi* sp. nov. All these may be traced to the north Atlantic province, to which Whittington attributes *Ceraurinella*(?), *Illaenus* (s.l.) and *Harpes* (s.l.) from the Derfel Limestone. The brachiopods of the fauna are more ambiguous. *Palaeostrophomena*(?) sp., *Cyrtomotella* sp., and *Kiaeromena*(?) sp. have Baltic affinities, and the genera occur in the Derfel Limestone. *Ptychoglyptus* is known from slightly higher horizons in Norway (4b or the *Climacograptus peltifer* zone; Spjeldnaes 1957 : 61), and from the Girvan area in Scotland (Williams 1962 : 193). *Camerella* and *Metacamerella* are both found in Scotland and America. Thus these latter three brachiopod genera, together with the trilobites, may indicate an intermingling of the Baltic and Scoto-Appalachian faunas, at least in the limestone facies, if not in the grits at Llanbabo or in the Careg-onen and Derfel sediments. It appears likely, from lithological evidence, that the source area of limestone deposition lay to the north of Anglesey, but probably still on the upfaulted Irish Sea Landmass.

The specimens examined either come from Greenly's collection or were collected by the author. Those with numbers prefixed by 'BB' (brachiopods) or 'In' (trilobites) have been donated to the British Museum (Natural History). Greenly's collection is now in the possession of the Geological Survey, and the specimen numbers bear the prefix 'Af'.

#### IV. SYSTEMATIC DESCRIPTION OF THE BRACHIOPODA

Order ORTHIDA Schuchert & Cooper 1932

Suborder ORTHIDINA Schuchert & Cooper 1932

Superfamily ORTHACEA Woodward 1852

Family HESPERONOMIIDAE Ulrich & Cooper 1936

Genus HESPERONOMIELLA Ulrich & Cooper 1936

*Hesperonomiella carmelensis* sp. nov.

(Pl. I, figs. 1-6)

1919 *Rafinesquina* cf. *llandeiloensis* (Davidson); Matley in Greenly : 142.

DIAGNOSIS. Semicircular to subquadrate *Hesperonomiella* about three-quarters as long as wide, hinge line equal to the greatest width, cardinal angles about 80-85°; valves subequally and gently convex, lateral and anterior commissures plane; pedicle valve slightly carinate with convex lateral flanks, interarea wide, plane, apsacline, delthyrium open, width at teeth one-quarter the width of the valve; brachial valve with shallow rounded sulcus dying out anteriorly, interarea wide, shorter than the ventral one, anacline, notothyrium wide and open; neither umbo incurved; ornament finely and unequally multicostellate, costellae flat-topped with



narrow interspaces, numbering thirty per 5 mm. at 5 mm. from the umbo, arising by bifurcation, every fifth or sixth costella more prominent; teeth triangular, dental lamellae widely divergent forwards and slightly divergent to the floor of the valve, short but not receding, continued as low ridges around the muscle scars; muscle scars triangular in outline and relatively confined to the delthyrium, in length one-quarter that of the valve, adductor and diductor scars expanding forwards and equal in length; median trunks of the *vascula media* slightly impressed, converging forwards from the ends of the diductor scars to come in contact at half the length of the valve and then diverging again; cardinal process a simple lenticular septum with low lateral ridges parallel to its posterior half; brachiophores diverging at 80°, short and triangular in cross section, ends bevelled, largely adpressed to the valve surface; muscle scars and mantle canals not seen; subperipheral rim present.

TYPE SPECIMENS (measurements in mm.)

	Length	Width
HOLOTYPE. Internal mould of brachial valve (BB.30529) . . . . .	17.6	24.4
PARATYPES. Internal mould of pedicle valve (BB.30530) . . . . .	19.6	—
Internal mould of pedicle valve (BB.30531) . . . . .	19.2	26.9
Internal and external moulds of pedicle valve (BB.30532a-b) . . . . .	—	—
External mould of brachial valve (BB.30533) . . . . .	19.3	—

HORIZON AND LOCALITY. Carmel Formation, sandstone 50 yds. north-east of Prys-owain-bach, Carmel. N.G.R. 38878282.

DISCUSSION. Although the family Hesperonomiidae as erected by Ulrich & Cooper (1938 : 114) was defined as comprising forms with a chilidium, some of the species described by them have only rudimentary chilidial plates, which may be interpreted as a thickening of the inner edge of the interareas, and a swelling of the brachiophores (cf. Ulrich & Cooper 1938, Pl. 19, figs. 9, 10, 14, 17). Two genera were described, *Hesperonomia* with plano- or concavo-convex valves, and *Hesperonomiella* with gently biconvex valves. The new species therefore belongs in the latter genus. All the described species have a uniform ornament, whereas the new species is unequally parvicostellate. Internally the closest species is *Hesperonomia louisensis* Ulrich & Cooper, from the Sarbach formation, Alberta (Ulrich & Cooper 1938 : 120), which has almost identical ventral musculature and dorsal cardinalia, but has a concave brachial valve and equally parvicostellate ornament.

The specimens from the type locality are all very uniform in size, and to some extent distorted. The smallest pedicle valve had a length of 9.1 mm., and in a sample of eleven pedicle valves the average length was 16.6 mm., with a variance of 4.42, suggesting that the sample was current drifted with good sorting.

Genus *MONORTHIS* nov.

DIAGNOSIS. Quadrate shells, widest at a long straight hinge line, alate, with slightly acute cardinal angles; lateral profile flatly biconvex, with very low pyramidal pedicle valve and evenly convex brachial valve; pedicle valve with a low carinate fold with plane flanks, the rest of the surface evenly convex, almost flat; brachial valve with a deep rounded sulcus, swollen folds on either side of it, and concave lateral margins; lateral commissure flat, anterior commissure uniplicate; ventral interarea short and wide, apsacline to almost catacline, delthyrium open, dorsal interarea shorter, anacline, notothyrium open; surface finely multicostellate.

Ventral interior with receding dental lamellae, teeth and musculature not seen.

Dorsal interior with elevated notothyrial cavity; cardinal process a thin ridge; brachiophores thin and short, supported by a mass of callus, sockets thin and deep; adductor scars not seen but separated by a large median ridge corresponding to the exterior sulcus.

TYPE SPECIES. *Monorthis typis* sp. nov. from the Treiorwerth Formation.

DISCUSSION. The simple cardinalia in the brachial valve, together with the transverse shape and the convexity of valves, form the distinctive features of the genus. *Metorthis* Wang is similar in shape, but has a thickened cardinal process and muscle scars like those of *Dinorthis*, whereas this genus seems to have the confined muscle scars of *Orthis*. The genus is tentatively placed in the *Hesperonomiidae*, since it agrees with the diagnosis of that family (Ulrich & Cooper 1938 : 114) except that neither chilidial plates nor a chilidium are present. The structure interpreted by Ulrich & Cooper as chilidial plates may be no more than the thickening of the inner edge of the interarea where it forms the posterior part of the brachiophores.

*Monorthis typis* gen. et sp. nov.

(Pl. 1, figs. 7-13)

1919 *Orthis* (*Hebertella*) *vespertilio* J. de C. Sowerby; Matley in Greenly : 442.

DIAGNOSIS. Quadrate biconvex *Monorthis*, widest at a long straight hinge-line, alate, with slightly acute cardinal angles; lateral profile flatly biconvex, with very low pyramidal pedicle valve and an evenly convex brachial valve; pedicle valve with a low carinate fold with plane flanks, the rest of the surface evenly convex, almost flat, interarea short and wide, apsacline to almost catacline, delthyrium open; brachial valve with a deep rounded sulcus, swollen folds flanking it, and concave lateral margins, interarea shorter than the ventral one, anacline, notothyrium open; surface of both valves finely multicostellate, costellae numbering four per mm. at the shell margins but everywhere poorly preserved; ventral interior with receding dental lamellae, teeth not seen; musculature not seen but probably confined; low ridges marking the sides of the fold are aligned with the dental lamellae; dorsal interior with small elevated notothyrial platform; cardinal process a thin ridge; brachiophores short and thin, supported by a mass of callus cementing them

to the sides of the notothyrial cavity; sockets thin and deep; adductor scars probably small, and separated by a large median elevation corresponding to the exterior sulcus.

	Length	Width
TYPE SPECIMENS (measurements in mm.)		
HOLOTYPE. Internal mould of brachial valve (BB.30534) . . . . .	7·1	—
PARATYPES. Internal and external mould of brachial valve (BB.30535a-b) . . . . .	6·9	—
Internal and external moulds of pedicle valve (BB.30536a-b) . . . . .	7·1	11·0

TYPE HORIZON AND LOCALITY. Treiorwerth Formation, sandstones 300 yds. south-east of Ffynnon-y-mab, Trefor. N.G.R. 36247950.

DISCUSSION. The new species is generically distinct from other known orthoceans, and can be distinguished by features referred to in the generic description from various hesperonomiids with which it is most closely related. The poor preservation of the valves makes it impossible to carry out any analysis of the ribbing or of the various dimensions, except to remark that the average percentage length of five brachial valves relative to width was 62·6 (range 55·3–73·4).

Family **ORTHIDAE** Woodward 1852

Subfamily **ORTHINAE**

Genus **CYRTONOTELLA** Schuchert & Cooper 1931

*Cyrtonotella* sp. (1)

(Pl. 2, figs. 9, 10, 13)

FIGURED SPECIMEN (measurements in mm.)

	Length	Width
Internal and external mould of brachial valve (BB.30521a-b) . . . . .	—	—

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. Two valves have been found, one being very incomplete, the other a brachial valve in fair condition. It is semi-circular, with a slight sulcus. The hinge-line is straight, with an anacline interarea and probably an open notothyrium. The ornament is multicostellate; the margin has more than forty ribs but the details of the branching are obscure. Internally the cardinal process is simple and continuous with a median septum, the brachiophores are orthoid, diverging at 80°, and the sockets are elongated parallel to the hinge-line. These characters agree well with those of the brachial valve figured by Williams (*in* Whittington & Williams 1955, pl. 38, figs. 14–16), and referred to *Cyrtonotella* aff. *kukersiana* (Wysogorski).

*Cyrtonotella* sp. (2)

(P. 2, figs. 14-16)

	Length	Width
FIGURED SPECIMENS (measurements in mm.)		
Exterior of incomplete pedicle valve (BB.30522) .	7·9	—
Exterior of incomplete brachial valve (BB.30523) .	13·5	—
External mould of incomplete brachial valve (BB.30524) . . . . .	8·9	—

HORIZON AND LOCALITY. Garn Formation, Limestone blocks in breccia beds, Porth Padrig, Mynachdy. N.G.R. 30539279.

DISCUSSION. The valves have the external features of *Cyrtonotella*, but the interareas and the internal features are concealed. The pedicle valve is strongly convex, and is probably semi-circular in outline with a straight, slightly alate hinge-line; the interarea cannot be very long. The brachial valve is gently concave, with a slight median sulcus in one specimen (BB.30524). The ornament of both valves is slightly fascicostellate, with seven to twelve costellae per 5 mm. antero-medially, and the interspaces have closely spaced fine growth lines. The pattern of the branching of the ribs cannot be made out. Owing to the incompleteness of the valves it is not possible to compare them closely with any other species.

Genus *LENORTHIS* Andreeva 1955*Lenorthis proava* (Salter)

(Pl. 1, fig. 21; Pl. 2, figs. 1-8)

- 1866 *Orthis calligramma* var. *proava* Salter: Appendix 335-336, pl. 22, fig. 1.  
 1868 *Orthis Carausii* (Salter ms.); Davidson : 315, pl. 16, fig. 23.  
 1869 *Orthis Carausii* (Salter ms.); Davidson : 229, pl. 33, figs 1-7.  
 1869 *Orthis calligramma* var. *proava* Salter; Davidson : 241, pl. 35, figs. 13-15.  
 1883 *Orthis carausii* Salter; Davidson: 182-184, pl. 14, figs. 21-26.  
 1912 *Orthis proava* Salter; Matley : 78-79.

DIAGNOSIS. Subquadrate biconvex *Lenorthis* five-sixths as long as wide and one-third as deep as wide, the pedicle valve being twice as deep as the brachial valve; widest at the hinge line, with cardinal angles of approximately 90°, anterior and lateral commissures plane; pedicle valve convex, slightly carinate, interarea curved, apsacline, one-sixth the length of the valve; brachial valve gently convex with a shallow rounded median sulcus and concave flanks, interarea anacline, shorter than the ventral one; ornament of simple rounded costae with equal rounded interspaces, numbering sixteen to twenty, with a wave-length of 0·93 mm. at 5 mm. from the dorsal umbo, the pedicle valve bearing a median costa and the brachial valve four costae in the sulcus; costae covered by fine filae, growth lines rarely seen except at the margins of adult shells; ventral interior with blunt triangular teeth and small crural fossettes; dental lamellae vertical, receding; muscle scars confined to the delthyrium but details not seen, width three-twentieths that of the valve, length length unknown; dorsal interior with thick median septum running half the length of the valve; adductor scars quadripartite, on either side of the septum,



occupying four-tenths the width of the valve; margins of both valves crenulated.

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal mould of brachial valve (BB.30512)	10.5	15.1
Internal and external moulds of pedicle valve (BB.30513a-b)	11.7	15.8
Internal mould of pedicle valve (BB.30514)	distorted	
Internal and external moulds of brachial valve (BB.30515a-b)	11.0	—
Internal mould of pedicle valve (Af.1337)	11.4	15.0

HORIZON AND LOCALITIES. Carmel Formation, sandstones, 50 yds. north-east of Prys-owain-bach cottage, Carmel. N.G.R. 38878283. Specimen Af. 1337 is from the same horizon, 130 yds. north-west of Ty-hen, Treiorwerth. N.G.R. 35567872.

DISCUSSION. The specimens of *L. proava* from all the localities in the Carmel Grits are preserved in a coarse sandstone, so that the finer detail of the ornament and of the mantle canal patterns is lost. It is seldom possible to count all the costae, since the finer ribs close to the hinge line are not preserved, and the anterior border of the ventral muscle scars is not seen. These scars may be triangular in shape, with the adductors not enclosed by the diductors and equal in length to them. In ten brachial valves the costae 5 mm. anteromedianly from the umbo have a mean wavelength of 0.93 mm. (var 0.0141). In the interior of the brachial valve the anterior and posterior adductor scars are equal in area, the posterior pair deeply sunk beneath the notothyrial platform. The brachiophores are closely adpressed to the edges of the platform, and the ends are bevelled.

The majority of the figured specimens come from Prys-owain-bach, as here the species may be found in greatest abundance, and without much distortion. When first described by Salter, the locality was given as 'grits among the black shales of Llanerchymedd, Anglesey' (1866 : 336). No type locality is given for the figured specimens, which have since been lost. Earlier in the same work (259) the species, as *Orthis calligramma* var., is listed as occurring at a locality one mile north-west of Llanerchymedd, at Treiorwerth, and at Tyn-twr, 4 miles south of Llangefni. The first of these localities cannot easily be located, and good specimens are not found in that region; the second locality is that listed above at Ty-hen.

TABLE I

	(a)	(b)
$\bar{l}$ (var. l)	10.36 (5.017)	9.44 (2.600)
$\bar{w}$ (var. w)	12.12 (5.438)	12.70 (3.736)
r	0.753	0.787
a (var. a)	1.041 (0.01339)	1.199 (0.01092)
a (var. b)	1.34 (1.513)	1.38 (1.0054)

TABLE I. Statistics of length (l) and width (w) of (a) thirty-five pedicle valves and (b) fifty brachial valves of *Lenorthis proava* (Salter) from sandstones 50 yds. north-east of Prys-owain-bach, Carmel.

*Lenorthis* sp.

(Pl. 2, figs. 11-12)

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal mould of pedicle valve (BB.30601a)	—	—
Internal mould of brachial valve (BB.30602)	11.7	14.6 (est.)

HORIZON AND LOCALITY. Bod Deiniol Formation, grits in temporary excavation 50 yds. north of Ty-bach cottage, Bod Deiniol. N.G.R. 37688528.

DISCUSSION. The species is very similar to *Lenorthis proava*, and is probably closely related. The ratio of length to width of the brachial valve is very similar; in five valves the mean length is 9.56 mm. and width 12.68 mm. There may, however, be more costae, as at least twenty-four can be counted in some specimens, and their wavelength 5 mm. from the umbo in the brachial valves is approximately 0.75 mm. compared with 0.95 mm. in *L. proava*.

Genus *ORTHAMBONITES* Pander 1830*Orthambonites* (?) sp. (1)

(Pl. 1, figs. 14, 16, 17)

1919 *Orthis* cf. *proava* Salter; Matley in Greenly : 452.

FIGURED SPECIMEN (measurements in mm.)

	Length	Width
Internal and external moulds of brachial valve (Af.1398-9)	6.9	—

HORIZON AND LOCALITY. Nantannog Formation, gritty shales by well on the west side of the road, 220 yds. west of Fferam-uchaf. N.G.R. 36188667.

DISCUSSION. The valve has about twenty rounded costae, with late internal and external bifurcations, and with fine parvicostellae in the interspaces. In shape the valve is semicircular, with rounded cardinal angles and the greatest width just anterior to them, gently convex and slightly sulcate. The internal details are similar to those of *Lenorthis proava* (Salter). Division of the costae is described by Cooper (1956) in two species, *O. bifurcatus* and *O. divaricatus*. The latter species, with its few late bifurcations, is very similar.

*Orthambonites* (?) sp. (2)

(Pl. 1, figs. 15, 18-20)

DESCRIPTION. Small subcircular *Orthambonites* or *Lenorthis* with the more convex pedicle valve four-fifths as long as wide and one quarter as deep as long, ornamented by about seventeen rounded costae with a wavelength of 0.7 mm. at 5 mm. from the ventral umbo.

## FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal mould of pedicle valve (BB.30510) . . . . .	10·7	12·0
Internal and external moulds of pedicle valve (BB.30511a-b) . . . . .	4·9	6·3

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. A few pedicle valves of *Orthambonites*(?) have been found from the Llanbabo Grits, together with a few fragmentary brachial valves. The numbers found are too few to analyse statistically, the mean length and width of three pedicle valves being 8·7 mm. and 10·1 mm. respectively. The species recalls *O. parvicrassicostratus* Cooper, from the Caradoc of the Girvan area (Williams 1962 : 98), which has about nineteen costae on the pedicle valve, angular in cross section. Neither this species nor the preceding one can be definitely assigned to *Orthambonites*, since the course of the *vascula media* has not been observed.

Genus **PLEURORTHIS** Cooper 1956

***Pleurorthis costatus*** sp. nov.

(Pl. 2, figs. 17-19; Pl. 3, figs. 1-4, 6)

DIAGNOSIS. Subequally biconvex, transverse, subquadrate to semicircular *Pleurorthis*, length seven-tenths the maximum width, which is at or just anterior to the hinge-line; cardinal angles rounded to slightly acute; lateral commissures almost straight, anterior commissure uniplicate; pedicle valve initially with a median fold, reversing to form a sulcus with gently curved flanks at about 3-4 mm. from the umbo; ventral interarea slightly curved, apsacline, about one-fifth the length of the valve; brachial valve initially with a slight sulcus, reversing to form a fold corresponding to the ventral sulcus, interarea wide, anacline, shorter than the ventral one, notothyrium open; ornament on both valves of sharp angular costae, about ten being primary, increasing by bifurcation and numbering about eight per 5 mm. antero-medially at 5 mm. from the umbo, growth lines not seen; in ventral interior teeth blunt, triangular, dental lamellae descending vertically to the floor of the valve and slightly receding, diverging anteriorly at 70°; muscle scars largely confined to the delthyrial cavity, elevated on a callosity ending anteriorly in a blunt forward pointing 'V'; adductor track equal in width to one diductor scar, both sets of scars expanding forwards; *vascula media* trunks parallel and submedian; in dorsal interior notothyrial platform low, one-sixth the width of the valve; cardinal process a simple ridge; brachiophores blade-like, diverging from each other at more than 90°, supported only by the notothyrial platform; sockets are pits just below the hinge-line; adductor scars extend to the midlength of the valve, separated by a median ridge of the same length, the posterior pair the smaller, wider than long, anterior pair triangular, coming to a blunt point close to the ridge; costellae impressed on the inner surface of young valves.

TYPE SPECIMENS (measurements in mm.)		Length	Width
HOLOTYPE.	Internal mould of brachial valve (BB.30516)	10.5	19.9
PARATYPES.	Internal and external moulds of pedicle valve (BB.30517a-b)	10.8	—
	Internal mould of pedicle valve (BB.30518)	12.0	—
	Internal and external moulds of brachial valve (BB.30555a-b)	7.9	—

TYPE HORIZON AND LOCALITY. Treiorwerth Formation, sandstones, 300 yds. south-east of Ffynnon-y-mab, Trefor. N.G.R. 36247950.

DISCUSSION. The new species conforms to the generic diagnosis of *Pleurorthis*, but differs markedly from the species described by Cooper (1956 : 329-333). The ornament is much more coarsely costellate than even the coarsest described by him, the development of fold and sulcus is much more pronounced, and internally the described species have no excessive development of secondary calcite in the larger shells. This last trend in the new species gives rise to a pseudospondylium, and leads to the obliteration of all internal impressions of the costellae.

TABLE 2

	(a)	(b)
l (var. l)	8.56 (3.433)	7.55 (2.891)
w (var. w)	12.26 (5.610)	11.40 (6.181)
r	0.867	0.842
a (var. a)	1.124 (0.00653)	1.462 (0.01152)
b (var. b)	2.639 (0.5091)	0.368 (0.6392)

TABLE 2. Statistics of length (l) and width (w) of (a) forty-eight pedicle valves, and (b) fifty-four brachial valves of *Pleurorthis costatus* sp. nov. from sandstones 300 yds. south-east of Ffynnon-y-mab, Trefor.

### Subfamily **PRODUCTORTHINAE** Schuchert & Cooper 1931

#### Genus *NICOLELLA* Reed 1917

#### *Nicolella humilis* Williams

(Pl. 3, figs. 5, 7-9)

#### FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal and external moulds of brachial valve (BB.30519a-b)	10.5	18.4 (est.)
Internal and external moulds of brachial valve (BB.30520a-b)	10.1	—



HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. Specimen BB.30520 has, as far as can be seen, an identical ribbing pattern to that of *N. humilis*, with possibly eighteen primary costae, though no secondary costae are developed, because of the small size of the valve. BB.30519 is also referred to this species; there appear to be only fourteen primary costae, allowing for state of preservation, and internal and external secondary costae originate at 5.6 mm from the umbo.

Genus *PANDERINA* Schuchert & Cooper 1931

*Panderina lamellosa* sp. nov.

(Pl. 3, figs. 10-18)

DIAGNOSIS. A species of *Panderina* with semicircular alate valves, three-quarters as long as wide, the pedicle valve with the greater convexity, evenly convex medianly with concave lateral flanks; the brachial valve gently convex with a shallow sulcus, narrow posteriorly but rapidly widening; anterior commissure slightly uniplicate; radial ornament of low rounded costellae arising by implantation, crossed by imbricate growth lamellae, which become crowded together at the shell margin in fully grown forms, especially on the brachial valve; ventral interior with stout dental lamellae descending directly to the floor of the valve, extended as low ridges bounding an ovate muscle area; teeth blunt, with large and prominent crural fossettes lying close beneath them and rimmed by accessory teeth; dorsal interior with large cardinalia projecting above the hinge line, the width between the brachiophore tips being four-tenths the width of the valve; brachiophores blade-like, with massive knob-like ends, diverging at 90° and adpressed to the notothyrial platform; cardinal process a bulbous myophore without shaft, joined to the brachiophores at its posterior end; muscle scars extend to the longitudinal midline of the valve, the anterior pair the larger, not bilobed.

TYPE SPECIMENS (measurements in mm.)

	Length	Width
HOLOTYPE. Internal and external moulds of brachial valve (BB.30525a-b) . . . . .	5.2	—
PARATYPES. Internal and external moulds of pedicle valve (BB.30526a-b) . . . . .	4.8	6.7
Internal and external moulds of pedicle valve (BB.30527a-b) . . . . .	—	9.0 (est.)
Internal and external moulds of brachial valve (BB.30528a-b) . . . . .	6.8	9.0 (est.)

TYPE HORIZON AND LOCALITY. Treiorwerth Formation, sandstones 300 yds. south-east of Ffynnon-y-mab, Trefor. N.G.R. 36247950.

DISCUSSION. The known species of *Panderina* were all erected by Pander and Lamansky (Schuchert & Cooper 1932 : 82), and form a homogeneous group of shells with characteristics 'intermediate between *Orthis* s.s. and *Productorthis*'. All have

plano- or concave-convex shells, short interareas, simple cardinalia, and are imbricate anteriorly. The new species has imbricate growth lamellae, but they are not confined to the front of the shell. The brachial valve is also distinctly convex, though the specimens are distorted and the degree of convexity cannot be accurately measured. The cardinalia approach the *Productorthis* type, and are larger than in the other described species. It can be seen therefore that the new species has characters which place it a little further towards *Productorthis* than the other species of *Panderina*.

Family **DOLERORTHIDAE** Öpik 1934

Subfamily **DOLERORTHINAE** Öpik 1934

Genus **DOLERORTHIS** Schuchert & Cooper 1931

*Dolerorthis* cf. *tenuicostata* Williams 1955

(Pl. 4, figs. 4, 6-7)

FIGURED SPECIMEN (measurements in mm.)

	Length	Width
Internal and external moulds of pedicle valve (BB.30541a-b)	11.0	—

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. One specimen has been found, and shows the interarea and umbonal regions. Externally the ribs appear similar to those of *D. tenuicostata*, but since the specimen is not complete the patterns cannot be compared. Internally the muscle scars are of the same pattern, though the ridges bounding the diductor scars make an angle of 90° with each other while in the holotype of the species this angle is about 60°. The *vascula media* are typical of the genus. Since the brachial valve has not been found, and the full ribbing pattern cannot be analysed, the specific identification is not certain.

Subfamily **GLYPTORTHINAE** Schuchert & Cooper 1931

Genus **PTYCHOPLEURELLA** Schuchert & Cooper 1931

*Ptychopleurella* sp. (1)

(Pl. 3, figs. 19-23)

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal and external moulds of pedicle valve (BB.30537a-b)	3.5	—
Internal and external moulds of brachial valve (BB.30538a-b)	4.5	—

HORIZON AND LOCALITY. Nantannog Formation, fine sandstones and shales south-east of Fferam-uchaf farm, Llanbabo. N.G.R. 36518657.

DISCUSSION. The valves have the typical form of *Ptychopleurella*: the pedicle valve is sub-pyramidal, with a long, almost catacline interarea, the brachial valve is convex, with a median sulcus and a shorter, almost orthocline interarea, and both valves have typical interiors for the genus. The ornament is of simple, angular costae, fourteen on the brachial valve, with two in the sulcus, originating just anterior to the umbo. It is crossed by imbricate growth lamellae, crowded together in the first 5 mm. of growth, subsequently occurring at three per mm.

Only three pedicle valves and two brachial valves have been found, so that no good estimates of the size and shape parameters of the stock can be gained. The ratios of length to width as a percentage of the pedicle valve are 56.3, 58.8 and 79.7, and of the brachial valves 60.0 and 70.0. Without more material it is impossible to make any good comparisons with described species. In the simple ribs this species contrasts with *Ptychopleurella* sp. (2) from Llanbabo, and is similar to other early species, such as *P. oklahomensis* Cooper from the McLish formation, Llanvirn Series (Cooper 1956 : 388).

*Ptychopleurella* sp. (2)

(Pl. 4, figs. 1-3, 5)

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal mould of incomplete brachial valve (BB. 30539a-b) . . . . .	—	—
Internal and external moulds of incomplete pedicle valve (BB. 30540a-b) . . . . .	6.8	8.6 (est.)

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. The valves found are small, biconvex and transverse, with a strongly convex pedicle valve with a median flattening and a strongly apsacline interarea, and a convex brachial valve with possibly a slight median fold and an almost orthocline interarea. The ornament is of coarse angular costae, increasing by implantation and crossed by close imbricate growth lamellae numbering eight per mm. at 6 mm. from the ventral umbo. Internally the dental lamellae are receding; the ventral musculature is well defined and elevated on a pseudospondylium, the adductor tracks being wide and shorter than the diductor tracks; the cardinalia are large, the cardinal process being a simple ridge somewhat thickened on its anterior edge.

The species is similar to the later species of *Ptychopleurella*, e.g. *P. bouchardi* (Davidson) from the middle Silurian, which have ribbing patterns characterized by late developing secondary costae. The slight median fold of the brachial valve, if found on other specimens, may prove to be a diagnostic feature, since it is not found in other species of the genus.

Family **PLAESIOMYIDAE** Schuchert 1913Subfamily **PLAESIOMYINAE** Schuchert 1913Genus **PLAESIOMYS** Hall & Clarke 1892***Plaesiomys* cf. *robusta*** (Bancroft)

(Pl. 4, figs. 8-12)

## FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal and external moulds of pedicle valve (BB.30544a-b) . . . . .	23.5	32.5
Internal and external moulds of pedicle valve (BB.30545a-b) . . . . .	25.0	26.6 (est.)
Internal and external moulds of brachial valve (BB.30543a-b) . . . . .	15.0	—

HORIZON AND LOCALITY. Crewyn Formation, grits in small outcrop 420 yds. west-south-west of Ysgubor-gader, Mynachdy. N.G.R. 29589214.

DISCUSSION. Both valves have the typical characters of *Plaesiomys* in shape, ventral musculature, and cardinalia. The very poorly preserved external moulds have costellate ribbing. The pedicle adjustor scars are very distinct, the diductor scars slightly bilobed, and the adductor scars not differentiated. The length of the two pedicle valves varies from 70-90 per cent. of their width. Strong internal plications extend inwards from the margin. These features are listed by Bancroft (1945 : 244-245) as characteristic of *P. robusta*. He gives little idea of the natural variation within the species, and unfortunately does not figure a typical pedicle valve, but only one described by him as abnormal.

***Plaesiomys* (*Dinorthis*) sp.**

(Pl. 4, figs. 13-15)

## FIGURED SPECIMEN (measurements in mm.)

	Length	Width
Internal and external moulds of pedicle valve (BB.30542a-b) . . . . .	8.0	10.0

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. The valve is of a subquadrate *Dinorthis*, convex at the umbo, but becoming flat towards the commissure, the interarea short and apsacline, with an open delthyrium, and a simple costate ornament of eighteen costae, becoming broad and flat-topped towards the anterior. In the interior the muscle scars are subquadrate and slightly indented medianly, though the individual scars cannot be separated. The dental lamellae are widely divergent. The shape of the valve,

and the number of costae suggest a young specimen of *D. flabellulum* (J. de C. Sowerby).

Family **PLECTORTHIDAE** Schuchert & Le Vene 1929

Subfamily **PLECTORTHINAE** Schuchert & Le Vene 1929

Genus **PLECTORTHIS** Hall & Clarke 1892

*Plectorthis* (?) sp.

(Pl. 4, figs. 16, 19)

1919 *Orthis* (*Dalmanella*) *testudinaria*? Dalman; Matley in Greenly : 452.

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal mould of pedicle valve (Af. 1377) . . . . .	6.6	8.0
Internal mould of pedicle valve (Af. 1462) . . . . .	8.5	—

HORIZON AND LOCALITY. Nantannog Formation, gritty shales 250 yds. west-south-west of Fferam-uchaf, Llanbabo. N.G.R. 36178655.

DISCUSSION. The valves are convex, suboval in outline with a straight hinge-line narrower than the maximum width, and a short curved apsacline interarea and open delthyrium. The ornament is finely costellate. The teeth are not seen, the dental lamellae are thin and sub-parallel, the muscle scars extend one-third the length of the valve with the adductor and diductor scars the same length and with a rectangular end.

Subfamily **PLATYSTROPHIINAE** Schuchert & Le Vene 1929

Genus **PLATYSTROPHIA** King 1850

*Platystrophia precedens major* Williams 1955

(Pl. 4, figs. 17-18)

FIGURED SPECIMEN (measurements in mm.)

	Length	Width
Internal and external moulds of pedicle valve (BB. 30546a-b) . . . . .	13.5	—

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. Isolated valves referable to *Platystrophia* have been found at Careg-onen, Trwyn y Crewyn and Llanbabo. Only at the last locality are the valves complete enough for a specific identification, and appear to be identical with specimens from the Derfel Limestone (Whittington & Williams 1955 : 402, pl. 38, figs. 24-29). The other specimens, in all probability from the same horizon, also belong to the bicostate species group.



Family **SKENIDIIDAE** Kozłowski 1929Genus **SKENIDIOIDES** Schuchert & Cooper 1931*Skenidioides* sp. (1)

(Pl. 5, figs. 1-2)

## FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal mould of pedicle valve (BB.30547) . . . . .	2·3	3·0
Internal mould of brachial valve (BB.30548) . . . . .	3·2	—

HORIZON AND LOCALITY. Treiorwerth Formation, sandstones 300 yds. south-east of Ffynnon-y-mab, Trefor. N.G.R. 36247950.

DISCUSSION. The specimens are preserved as internal and external moulds in a coarse grit, and are too poorly preserved to identify specifically. In particular the costae are hardly preserved at all, though they are probably few in number, between 13 and 16, and simple. The pedicle valve is semicircular, pyramidal, with a long strongly apsacline interarea and a high-standing shallow spondylium supported by a short receding median septum. The brachial valve is gently convex and sulcate, and bears a well developed median septum running the length of the valve.

TABLE 3

$\bar{l}$ mm. (var. l)	2·47 (0·203)
$\bar{w}$ mm. (var. w)	3·53 (0·306)
r	0·723
a (var. a)	1·245 (0·0493)
b (var. b)	0·45 (0·3126)

TABLE 3. Statistics of length (l) and width (w) of fifteen pedicle valves of *Skenidioides* sp. (1).*Skenidioides* sp. (2)

(Pl. 5, figs. 3-5)

## FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal and external moulds of brachial valve (BB.30549a-b) . . . . .	2·3	—
Internal and external moulds of pedicle valve (BB.30550a-b) . . . . .	2·6	—

HORIZON AND LOCALITY. Nantannog Formation, fine sandstones and shales 190 yds. south-east of Fferam-uchaf, Llanbabo. N.G.R. 36518657.

DISCUSSION. The specimens are typical of the genus, but are very small. The pedicle valve is sub-pyramidal, with a shallow, largely free spondylium. The brachial valve has a good septalium, the supporting plates converging on a high median septum which runs most of the length of the valve. The ornament of both valves is of simple costae, apparently about fourteen in number.

This species is very similar to *Skenidioides* sp. (1) from the *D. hirundo* zone, but there seem to be minor differences between the interiors of the two species. The earlier species has a well developed median septum in the pedicle valve, possibly with a larger delthyrium. The dorsal sulcus also seems to be better developed in this species.

Superfamily ENTELETACEA Waagen 1884

Family PAURORTHIDAE Öpik 1933

Genus PAURORTHIS Schuchert & Cooper 1931

*Paurorthis* (?) sp.

(Pl. 5, figs. 6-9)

DESCRIPTION. Pedicle valve subcircular, evenly convex, about one-third as deep as long and slightly longer than wide; hingeline slightly less than the maximum width; interarea curved, apsacline, delthyrium open; ornament fascicostellate but not well preserved; umbonal cavity deep; muscle scars extending forwards beyond the umbonal cavity to almost half the length of the valve, elevated anteriorly; central (adductor?) scars occupying most of the width between the dental lamellae, flanked by narrow, slightly depressed (diductor?) tracks which extend onto the sides of the dental lamellae, which extend alongside them as ridges; teeth apparently aligned along the dental lamellae, crural fossettes present; vascula media at first converging from the ends of the diductor scars, then diverging; margin of valve crenulate.

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal mould of pedicle valve (BB.30603a)	9.5	10.2
Internal and external mould of pedicle valve (BB.30604a-b)	10.3	9.4

HORIZON AND LOCALITY. Bod Deiniol Formation, grits in temporary excavation 50 yds. north of Ty-bach Cottage, Bod Deiniol. N.G.R. 37688528.

DISCUSSION. Although a number of pedicle valves were collected, no brachial valves were found, nor was it possible to examine a thin section of the shell to determine the nature of the shell material. The fascicostellate ornament, disposition of the muscle scars and vascula media, and the short median ridge are all found in *Paurorthis*. Williams (1962 : 141) has commented on the development of the latter feature, which is better developed in the allied genus, *Cyclomyonia*.

The valves also show some similarities to certain dalmanellid-like members of the Orthidae and Finkelnburgiidae. Pedicle valves of *Nanorthis* have a similar shape, with sometimes a fasciculate ornament, but internally the shell is not thickened under the muscle scars; *Nothorthis* is similar but more transverse. *Archaeorthis* also has a *Dalmanella*-like exterior, but the muscle scars, although elevated, do not extend forwards from the umbonal cavity as in the Anglesey specimens. *Diparelasma* is another dalmanellid-like form, with the muscle scars elevated in a

pseudospondylium in front, and a short median ridge, but with a finely costellate ornament. In many respects the muscle scars and pseudospondylium are very similar.

Family **DALMANELLIDAE** Schuchert 1913

Genus **DALMANELLA** Hall & Clarke 1892

*Dalmanella* (?) sp.

(Pl. 5, figs. 10-11)

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
External mould of brachial valve (BB.30568) . . . . .	8.2 (est)	—
External mould of pedicle valve (BB.30569) . . . . .	7.2	8.4 (est.)

HORIZON AND LOCALITY. Crewyn Formation, grits 420 yds. west-south-west of Ysgubor-gader. N.G.R. 29589214.

DISCUSSION. The valves are small, and the interiors are very badly preserved, so that it is impossible to make out the details of the cardinalia in the brachial valve. Owing to the small size of the brachial valve the ribbing pattern is not fully developed, so that only the first internal and external branches are developed. The pedicle valve is deeply convex, and only slightly carinate, the brachial valve very gently convex with a shallow median sulcus.

Genus **ONNIELLA** Bancroft 1928

*Onniella* (?) sp.

(Pl. 5, figs. 12-14)

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal and external moulds of pedicle valve (BB.30570a-b) . . . . .	—	8.1
Internal mould of brachial valve (BB.30571) . . . . .	5.5	6.4

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. The valves are subcircular, biconvex, the pedicle valve having the greater convexity and the brachial valve a shallow sulcus. The ornament is only seen on the pedicle valve and is slightly fascicostellate with forty to fifty costellae on the margin and a wavelength of 0.23 mm. at 5 mm. from the ventral umbo. The ventral adductor scar is shorter than, but not enclosed by the diductor scars, from the ends of which run widely separated and diverging *vascula media*. The brachiophores are widely divergent, but the details of the fulcral and supporting plates are not seen. The former may not be present. The adductor scars in the brachial valve are quadripartite. The valves recall *Onniella* (*Soudleyella*) cf. *avelinei* Bancroft (Whittington & Williams 1955 : 407).



Family **HARKNESSELLIDAE** Bancroft 1928Genus **HARKNESSELLA** Reed 1917**Harknessella** (?) sp.

(Pl. 5, fig. 16)

FIGURED SPECIMEN (measurements in mm.)

	Length	Width
Exterior of pedicle valve (Af. 1492)	10·1	14·7

HORIZON AND LOCALITY. Garn Formation, limestone block in breccia bed, 300 yds. south-east of the summit of Mynydd-y-garn. N.G.R. 31759062.

DISCUSSION. The valve is convex and slightly carinate, with a costellate ornament, no other details can be seen. A carinate pedicle valve is a feature of *Harknessella*.

Genus **HORDERLEYELLA** Bancroft 1928**Horderleyella** (?) sp.

(Pl. 5, fig. 15)

FIGURED SPECIMEN. Incomplete internal mould of pedicle valve (BB.30572).

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. An internal mould of a pedicle valve from Llanbabo agrees with *Horderleyella?* sp. from the Derfel Limestone (Whittington & Williams 1955, pl. 38, fig. 30) in having similar small subcordate muscle scars, and possibly belonging to an undescribed species.

Family **LINOPORELLIDAE** Schuchert & Cooper 1931Genus **SALOPIA** Williams 1955**Salopia salteri gracilis** Williams

(Pl. 5, figs. 17-18)

FIGURED SPECIMEN. Incomplete internal mould of brachial valve (BB.30573.)

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. The cardinalia and the median septum are well preserved, and show that the specimens belong to the genus *Salopia*. Since the cardinalia are small, with a length of less than 20 per cent. of the valve length, it can be placed in the subspecies *S. salteri gracilis*.

Family **ANGUSTICARDINIIDAE** Schuchert & Cooper 1931Genus **RHYNCHORTHIS** nov.

DIAGNOSIS. Rostrate biconvex shells, the brachial valve with the greater convexity; rectimarginate or slightly uniplicate; hinge-line narrow; ventral interarea long and narrow, almost orthocline, delthyrium open; dorsal interarea shorter, almost orthocline, notothyrium open; ornament on both valves of simple rounded costae becoming vague towards the flanks.

Ventral interior with receding, almost obsolete dental lamellae; strong teeth, oval in shape and aligned along the lamellae; orthoid muscle scars, the adductor and diductor scars expanding forwards, the former not enclosed by the latter.

Dorsal interior with deep notothyrial cavity, cardinal process a simple ridge; brachiophores plate-like, short and thick, with supporting and socket plates; adductor muscle scars orthoid, differentiated into anterior and posterior pairs, the anterior pair the larger.

TYPE SPECIES. *Rhynchorthis rotundus* sp. nov. from the Treiorwerth Formation.

DISCUSSION. Schuchert & Cooper (1931 : 244) erected the subfamily *Angusticardininae*, with their new genus *Angusticardinia*, for orthids evolving towards the rhynchonellids, but still retaining more orthid characters than those of the rhynchonellids. *Rhynchorthis* conforms to the description of the subfamily in having interareas on both valves, together with both orthid and rhynchonellid characters. It differs, however, from *Angusticardinia* in a number of important features. The interareas, though narrow, are long, the dental lamellae are weak or obsolete, and there is no median ridge inside the brachial valve. It is not known whether the shell material of either genus is punctate; Öpik (1933 : 5, 6) thought that *Angusticardinia* was probably punctate.

*Apatorthis* (Öpik 1933 : 5, from the middle and upper Ordovician of Estonia) is another rhynchonelliform shell, but has short and narrow curved interareas of equal length, a well marked fold and sulcus, and angular costae. The shell is punctate and is placed by Öpik in the *Enteletacea*.

Schuchert & Cooper (1932 : 84) suggested that *Angusticardinia*, being 'the earliest rhynchonelliform shell known', may have been the ancestor of the rhynchonellids, evolving into *Rhynchotrema*. *Rhynchorthis* is contemporary with *Angusticardinia*, but seems to be closer in structure to the ancestral orthids. The hinge-line is not quite so narrow, the interareas are long, and the cruralium-like structure of *Angusticardinia*, in which the supporting plates meet a median ridge, is not developed.

***Rhynchorthis rotundus*** gen. et sp. nov.

(Pl. 5, figs. 19-26)

DIAGNOSIS. Species of *Rhynchorthis*, six-fifths as long as wide, dorsi-biconvex with brachial valve one-fifth as deep as long, pedicle valve one-eighth as deep as long, ornamented by about twelve simple costae; internal details as for genus.

## TYPE SPECIMENS (measurements in mm.)

		Length	Width
HOLOTYPE.	Internal mould of brachial valve (BB. 30551)	10·1	8·4
PARATYPES.	Internal mould of brachial valve (BB. 30552)	11·1	—
	Internal mould of brachial valve (BB. 30553)	—	—
	Internal mould of pedicle valve (BB. 30554)	—	—
	Internal mould of pedicle valve (BB. 30556)	12·4	9·5

TYPE HORIZON AND LOCALITY. Treiorwerth Formation, sandstones 300 yds. south-east of Ffynnon-y-mab, Trefor. N.G.R. 36247950.

DISCUSSION. The new species is known from a number of rather poorly preserved moulds, particularly so in the case of the external moulds. The mean length per cent. of 5 pedicle valves relative to the width is 121·0 (variance 195·0). The corresponding figures for 5 brachial valves are 107·4 and 121·5. In the five brachial valves the mean depth per cent. relative to length is 20·6 (variance 29·2).

Suborder CLITAMBONITIDINA Öpik 1934

Superfamily **CLITAMBONITACEA** Winchell & Schuchert 1893

Family **POLYTOECHIIDAE** Öpik 1934

Genus **TRITOECHIA** Ulrich & Cooper 1936

*Tritoechia* sp.

(Pl. 6, figs. 1-3, 5)

## FIGURED SPECIMEN (measurements in mm.)

	Length	Width
Internal and external moulds of pedicle valve (BB.30557a-b)	17·0	19·8 (est.)

HORIZON AND LOCALITY. Treiorwerth Formation, sandstones 300 yds. south-east of Ffynnon-y-mab, Trefor. N.G.R. 36247950.

DISCUSSION. Only one well preserved pedicle valve, the figured specimen, and a few other poorly preserved pedicle valves have been found. No brachial valves have been found which can definitely be assigned to the genus.

The valve conforms externally to the genus *Tritoechia*. In outline it is semi-circular, widest at the hinge-line, with cardinal angles just acute. The surface is evenly convex, the umbo not incurved or inflated, and the interarea plane, apsacline but almost catacline. The delthyrium is covered by a strongly convex deltidium, but the foramen is not preserved. The ornament, which is poorly preserved, is finely multicostellate, with about fourteen costellae in 5 mm. both at the margin

and near the umbo. Internally the teeth are strong and rounded, supported by receding dental lamellae which diverge ventrally. The form and extent of the muscle scars are not known.

Among the species of *Tritoecchia* described by Ulrich & Cooper (1938 : 162-169) are a number which approach the valve closely, the nearest being *T. transversa*, which has an interarea more inclined towards the orthocline.

Family **CLITAMBONITIDAE** Winchell & Schuchert 1893

Subfamily **CLITAMBONITINAE** Winchell & Schuchert 1893

Genus **CLITAMBONITES** Pander 1830

*Clitambonites* (?) sp.

(Pl. 6, fig. 4)

FIGURED SPECIMEN. Fragmentary external mould of brachial valve (BB.30558).

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. The external mould is of a large, probably subquadrate brachial valve in excess of 18 mm. long by 26 mm. wide, gently convex, becoming flat or slightly sulcate medianly. The ornament is multcostellate, with perhaps four costellae per cm. at 5 mm. from the umbo, and at the margin eighteen per cm. At least ten more prominent ribs divide the ornament into sectors, each with four to six smaller ribs, arising both by implantation and bifurcation. Strong thick growth lamellae occur at intervals. The convex shape, and prominent growth lamellae, are both features of *Clitambonites*. *Clinambon* and *Vellamo* both have much less prominent growth costellae.

Genus **ILMARINIA** Öpik 1934

*Ilmarinia* sp.

(Pl. 6, figs. 6-7)

FIGURED SPECIMEN. Internal and external moulds of incomplete pedicle valve (BB.30559a-b).

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. Two counterpart moulds of the pedicle valve of a clitambonitaceid from Llanbabo show a subquadrate outline, a long apsacline interarea, and a slight sulcus. The delthyrium is possibly open, or constricted by deltidial plates, because there are certainly traces of a large foramen, and the ornament is finely multicostellate. Internally there is a good spondylium, one-third the width of the valve, and elevated by its own depth from the floor of the valve. It has a flat floor, and (though the specimen is broken) shows what may be the beginning of a thin receding median septum. *Ilmarinia* is the only clitambonitaceid genus with a ventral sulcus, and hence the specimen probably belongs here.

Subfamily **ATELELASMATINAE** Cooper 1956

Genus **APOMATELLA** Schuchert & Cooper 1931

*Apomatella* (?) sp.

(Pl. 6, figs. 8-11)

**DESCRIPTION.** Pedicle valve subquadrate, wider than long, widest at the hinge-line with the cardinal angles right angles; deeply pyramidal, slightly flattened medianly, interarea catacline or strongly apsacline, slightly curved, twice as wide as long; delthyrium probably open; ornament finely costellate; spondylium simplex high, shallow in cross-section; median septum receding.

**FIGURED SPECIMENS** (measurement in mm.)

	Length	Width
Internal and external moulds of pedicle valve (BB.30605a-b) . . . . .	—	8.8
Internal and external moulds of pedicle valve (BB.30606a-b) . . . . .	10.9	13.4 (est.)

**HORIZON AND LOCALITY.** Bod Deiniol Formation, Grits in temporary excavation 50 yds. north of Ty-bach Cottage, Bod Deiniol. N.G.R. 37688528.

**DISCUSSION.** A number of pedicle valves have been found at this locality, none with any trace of plates restricting the delthyrium, suggesting that the absence of plates is more than an accident of preservation.

Superfamily **GONAMBONITACEA** Schuchert & Cooper 1931

Family **GONAMBONITIDAE** Schuchert & Cooper 1931

Subfamily **GONAMBONITINAE** Schuchert & Cooper 1931

Genus **ANTIGONAMBONITES** Öpik 1934

*Antigonambonites pyramidalis* sp. nov.

(Pl. 6, figs. 12-18)

**DIAGNOSIS.** Outline sub-rectangular, wider than long, hinge-line just less than maximum width, anterior and lateral commissures rectimarginate; biconvex, pedicle valve pyramidal, with a long almost catacline interarea, slightly curved, brachial valve slightly convex, with a shallow median sulcus, interarea short and anacline; delthyrium probably closed or restricted by convex deltidial plates; notothyrium restricted but not closed by chilidial plates; ornament costellate, costellae numbering four per mm. at 5 mm. from the umbo, stronger ribs appearing at intervals, ribs crossed by well marked growth lines giving a slightly imbricate appearance; teeth not seen in ventral interior, but muscle scars impressed on a largely sessile *spondylium triplex*, supported at its anterior end by two lateral septa, the median septum being almost obsolete, adductor and diductor scars expanding forwards, the adductor tracks separated from the diductor tracks by raised ridges; dorsal interior with brachiophores long and widely divergent, measuring between



their tips over half the width of the valve, median septum very short or absent, cardinal process simple; adductor muscle scars within a semicircular track bounded by the brachiophores and by an indented ridge; margin crenulated.

TYPE SPECIMENS (measurements in mm.)

	Length	Width
HOLOTYPE. Internal and external moulds of brachial valve (BB.30561a-b) . . . . .	5·8	7·5
PARATYPES. Internal mould of pedicle valve (BB. 30562) . . . . .	—	—
Internal mould of brachial valve (B.30563)	9·9	—
Internal mould of pedicle valve (BB. 30564) . . . . .	6·8	—

TYPE HORIZON AND LOCALITY. Treiorwerth Formation, sandstones 300 yds. south-east of Ffynnon-y-mab, Trefor. N.G.R. 36247950.

DISCUSSION. The poor preservation of the specimens, and the fact that they are preserved as natural moulds and not as complete specimens with the original shell material, means that it is impossible to study the form and structure of the spondylium in detail. Since, however, it is a *spondylium triplex* the specimens belong to the Gonambonitidae. *Antigonambonites* Öpik is the closest described genus, being biconvex and having a largely sessile spondylium. The described species are generally flatly lenticular, with an apsacline interarea in the pedicle valve. The ornament is similar to that of *A. costatus* Öpik (1934 : 156), in which the costellae are conspicuous and angular, though in this species some costellae are accentuated. The pedicle valve is also deeper, in shape like that of *Skenidioides*, and has a similarly inclined interarea. The deltidial plates are poorly preserved in the moulds, and it is impossible to say whether they meet medianly or not. The mean percentage length relative to width of 5 brachial valves is 76·0, with a range from 58·2 to 92·9.

Genus **ESTLANDIA** Schuchert & Cooper 1931

*Estlandia* (?) sp.

(Pl. 7, figs. 2-4, 6-9)

1919 *Petraia* sp. Greenly : 435.

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal and external moulds of incomplete pedicle valve (Af.238, Af.225) . . . . .	—	—
Internal mould of brachial valve (Af.214) . . . . .	5·4	—
Internal and external moulds of brachial valve (BB.30560a-b) . . . . .	distorted	

HORIZON AND LOCALITY. Berw-uchaf Grits, 90 yds. north of Bwlch-gwyn farm, Holland Arms. N.G.R. 48207303.

DISCUSSION. The pedicle valve is strongly pyramidal, with a long apsacline interarea, possibly with an open delthyrium and with a costellate surface, the costellae having the 'chain-sculpture' characteristic of *Estlandia*. The interior has a well developed *spondylium triplex*, with a thick median septum, and thinner lateral septa parallel to the median septum. The interior of the brachial valve has long widely divergent brachiophores, thickened at their outer ends. The adductor muscle scars are half the length of the valve, pentagonal in form, with crenulated antero-lateral margins. They are separated by a thin median septum which joins the brachiophores at their inner ends to form an anchor-shaped structure.

The valves are provisionally placed in *Estlandia* as the ornament of the pedicle valve is quite characteristic of that genus. The side septa of *Estlandia*, however, are usually short and widely spaced, rather than close to the median septum.

Family **KULLERVOIDAE** Öpik 1934

Genus **KULLERVO** Öpik 1932

***Kullervo* aff. *panderi*** (Öpik)

(Pl. 6, figs. 19-22; Pl. 7, fig. 1)

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal mould of pedicle valve (BB.30565) . . .	distorted	
Internal mould of pedicle valve (BB.30566) . . .	3.3	7.5
Internal and external moulds of brachial valve (BB.30567a-b) . . . . .	4.5	8.5

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. The specimens are certainly conspecific with *Kullervo* aff. *panderi* (Öpik) described by Williams (Whittington & Williams 1955 : 412, pl. 30, figs. 56-62) and, like it, differ from Öpik's species only in the poorer development of the hemi-syrinx. The cardinal angles are slightly alate, and on them the concentric ornament is more pronounced than medianly (cf. Öpik 1934 text-fig. 37). The ventral interarea is almost catacline and appears to have an open delthyrium; since the specimens are small this is probably a characteristic of young stages, as suggested by Williams (Whittington & Williams 1955 : 412). There are no sub-spondylial septa.

Suborder CLITAMBONITIDINA Öpik 1934

Superfamily and genus uncertain

(Pl. 7, figs. 5, 10-11)

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal mould of pedicle valve (BB.30607) . . .	—	—
Internal and external moulds of brachial valve (BB.30608a-b) . . . . .	8.0	14.6

HORIZON AND LOCALITY. Bod Deiniol Formation, grits in temporary excavation 50 yds. north of Ty-bach Cottage, Bod Deiniol. N.G.R. 37688528.

DISCUSSION. Two valves found in the Nantannog Beds at the site of the Alaw reservoir cannot be assigned to any clitambonitid species. In particular it is not certain whether they belong together. The pedicle valve has a very long interarea, with deltidial plates, dental lamellae which converge to the floor of the valve, possibly with side septa, and with a prominent central groove in the floor of the delthyrium; the ornament is coarsely costellate. If the structure is a spondylium simplex then the valve may belong to the Polytoechiidae, as the median septum seems only to be rudimentary. The brachial valve is quadrate in outline, slightly alate, convex with a shallow median sulcus, and a short, almost orthocline interarea, possibly with a small chilidium; the ornament is coarsely costellate and imbricate. Internally the cardinalia are elevated on a notothyrial platform, which passes into a broad median septum; the cardinal process is a simple ridge, with widely divergent socket ridges; the muscle scars have two pairs of septa lying lateral to them, parallel to the median septum.

Order STROPHOMENIDA Öpik 1934

Suborder STROPHOMENIDINA Öpik 1934

Superfamily PLECTAMBONITACEA Jones 1928

Family PLECTAMBONITIDAE Jones 1928

Subfamily AHTIELLINAE Öpik 1933

Genus *AHTIELLA* Öpik 1932

*Ahtiella quadrata* sp. nov.

(Pl. 8, figs. 1-9)

DIAGNOSIS. Alate, subrectangular *Ahtiella*, two-thirds as long as wide; brachial valve convex, with a median sulcus widening and deepening anteriorly, flanked by rounded folds and slightly concave flanks near the cardinal angles; anterior commissure bent ventrally in some specimens; interarea anacline, notothyrium possibly covered by a small convex chilidium at its apex; pedicle valve flat or concave, with a low carinate median fold, and the anterior and lateral commissures bent ventrally; delthyrium open, possibly covered by a small arched plate at its apex; interarea strongly apsacline, eight times as wide as long; ornament of about fifteen costellae in 5 mm. at 5 mm. from the ventral umbo, every third or fourth costella accentuated, pedicle valve with about three very oblique and indistinct wrinkles near the cardinal angles; teeth angular, aligned along the hingeline, supported by very short receding dental lamellae diverging to the floor of the valve; muscle scars rectangular, wider than long, adductor scars not enclosed by diductor scars, both pairs expanding linearly forwards, adductors enclosing an angle of 60° with an arcuate anterior margin, diductors blade-like, extending beyond the adductors, enclosing an angle of 75° between their outer margins; small depressions

beneath teeth are either pedicle adjustor scars or depressions to accommodate the socket ridges; two pairs of vague ridges radiate from the ends of the diductor scars; anterior and lateral margins abruptly deflected ventrally; cardinalia orthid, elevated on a notothyrial platform; cardinal process a simple ridge, thickened along its anterior edge, highest midway along its length and triangular in outline; socket ridges short and rod-like, diverging at about  $90^\circ$ , resting directly on the notothyrial platform and possibly continuous with an incipient chilidium; sockets broad excavations in the hinge-line, diverging at about  $90^\circ$  and each enclosing an angle of  $20^\circ$ ; prominent median septum separating the muscle scars, which are disposed in an arc about the umbo, extending just less than half the length of the valve, one pair lateral to the other.

TYPE SPECIMENS (measurements in mm.)

		Length	Width
HOLOTYPE.	Internal mould of pedicle valve (BB. 30609)	10.9	15.8
PARATYPES.	Internal mould of pedicle valve (BB. 30610)	13.3	21.2 (est.)
	Internal and external moulds of pedicle valve (BB. 30611a-b)	—	22.0 (est.)
	Internal and external moulds of brachial valve (BB. 30612a-b)	—	—
	Internal and external moulds of brachial valve (BB. 30613a-b)	—	—
	Internal and external moulds of brachial valve (BB. 30614a-b)	—	—

TYPE HORIZON AND LOCALITY. Torllwyn Formation, sandstones 50 ft. above the base of the succession on the north side of the faulted syncline, 45 yds. north of Ogof Gynfor, Llanbadrig. N.G.R. 37859490.

*Ahtiella concava* sp. nov.

(Pl. 7, figs. 12-22)

DIAGNOSIS. Semicircular slightly alate *Ahtiella*, six-tenths as wide as long; brachial valve evenly convex in lateral view, with a narrow median sulcus having a V-shaped cross-section, flanked by rounded folds; interarea anacline to almost orthocline, very short, notothyrium possibly covered by a small convex chilidium at its apex; pedicle valve convex in lateral view, becoming more strongly bent towards the anterior commissure, but with the convexity broken by a narrow carinate fold which becomes more rounded and vaguer away from the umbo; delthyrium covered by a small arched plate at its apex; interarea procline or catacline, one-thirteenth as long as wide; ornament on both valves too fine to be observed, but growth lines present near the margins of valves; teeth triangular, aligned along the hinge-line, supported by very short receding dental lamellae diverging to the floor of the valve; muscle scars rectangular, diductors extending further forwards



than adductors, but details not seen; vague ridges radiating from the diductor scars; anterior and lateral margins deflected ventrally in some specimens; dorsal cardinalia orthid, elevated on a notothyrial platform; cardinal process a simple ridge, triangular in side view and thickened along its anterior margin; socket ridges short and rod-like, diverging at 90°, sockets shallow excavations under the hinge-line; muscle scars separated by a prominent median septum, posterior scars rounded and set in excavations under the notothyrial platform, anterior scars elongate and lying along each side of the median septum, extending to almost half the length of the valve, flanked by three ridges on each side, radiating from the posterior scars; median septum cusp-shaped in lateral outline, highest at its mid-point, thickened and swollen in its anterior half.

TYPE SPECIMENS (measurements in mm.)

		Length	Width
HOLOTYPE.	Internal and external moulds of pedicle valve (BB.30615a-b) . . . .	17.2	23.8 (distorted)
PARATYPES.	Internal and external moulds of brachial valve (BB.30616a-b) . . . .	—	19.8 (distorted)
	Internal and external moulds of brachial valve (BB.30617a-b) . . . .	—	—
	Internal and external moulds of brachial valve (BB.30618a-b) . . . .	13.0	20.7 (est.)
	Internal and external moulds of pedicle valve (BB.30619a-b) . . . .	11.7	22.2 (distorted)

TYPE HORIZON AND LOCALITY. Bod Deiniol Formation, grits in temporary excavation 50 yds. north of Ty-bach Cottage, Bod Deiniol. N.G.R. 37688528.

DISCUSSION. The two Anglesey species of *Ahtiella* differ from each other mainly in external shape and ornament, and in the development of the internal ridges in the brachial valve. *A. quadrata* has a rectangular outline, with the pedicle valve almost flat across the visceral disc and the brachial valve gently convex; both fold and sulcus are shallow. The ventral interarea is apsacline, and the ornament unequally costellate. In contrast *A. concava* is semicircular in outline, the pedicle valve has a concave visceral disc, and the brachial valve is strongly convex; both fold and sulcus are carinate, and higher and deeper. The ventral interarea is procline to catacline, and the ornament, though not preserved, is probably much finer.

Both species differ in their combinations of characters from the Baltic species described by Öpik (1932; 1933) and Hessland (1949). Most of these are relatively much wider, with prominent rugae close to the hinge-line. The fold and sulcus of *A. concava* are much better developed than in any Baltic species, although in outline and convexity it is similar to *A. lirata* Öpik. *A. quadrata* is more quadrate than any of the Baltic forms, and less convex.



The mean percentage of length relative to width of five pedicle valves of *A. quadrata* was 64.7 (range 57.3–69.0). For *A. concava* the corresponding value for thirteen pedicle valves was 59.8 (range 51.7–77.0) and for eight brachial valves 62.1 (range 54.9–78.4). Correlation coefficients between length and width for these specimens were not significant, due to poor preservation and distortion of the specimens. For similar reasons it was not possible to make any accurate estimate of the thickness of the valves.

Genus **REINVERSELLA** nov.

DIAGNOSIS. Semicircular plectambonitaceans with small postolateral wings; abruptly geniculate, with the border deflected ventrally; ventral disc convex, dorsal disc flat, the anterior and lateral commissures with a frill or gutter deflected dorsally; ventral interarea apsacline, short and wide, dorsal interarea short, anacline, both delthyrium and notothyrium open; ornament of fine bifurcating costellae, crossed by irregular concentric rugae on the visceral disc.

Ventral interior with dental lamellae diverging widely both laterally and ventrally, continuous with low ridges round the muscle scars; muscle scars triangular, adductor and diductor scars equal in length.

Dorsal interior with cardinalia raised on a low notothyrial platform; cardinal process low, thin and blade-like, slightly swollen anteriorly; brachiophores short and triangular in section, continuous on their ventral faces with the interarea.

TYPE SPECIES. *Reinversella monensis* sp. nov. from the Treiorwerth Formation.

DISCUSSION. This genus is separated from *Inversella* Öpik because of the development of a second deflection of the anterior and lateral borders of the shell, which forms a sort of frill or gutter. A similar, but more elaborate frill is characteristic of *Limbimurina* Cooper (1956 : 851–852), which bears the same relationship to the strophomenacean *Leptaena* as the new genus does to *Inversella*. Two of the described species of *Inversella*, *I. borealis* Öpik and *I. angulata* Öpik, have a chilidium, and it may be present in the third species *I. perundosa* Öpik. In contrast the new genus has an open notothyrium.

***Reinversella monensis*** gen. et sp. nov.

(Pl. 8, figs. 10–17)

1919 *Leptaena rhomboidalis* (Wilckens), *partim.*; Matley in Greenly : 442.

DIAGNOSIS. A species of *Reinversella* three-quarters as wide as long, and about one-third as deep as wide, ornamented with fine bifurcating costellae numbering fourteen to seventeen per 5 mm. on the rim of the visceral disc, crossed by seven to nine rugae, continuous or anastomosing across the midline; in the ventral interior the width of the muscle scars is about one-fifth the width of the valve and their length one-quarter the length of the valve; the width of the cardinalia is one-fifth the width of the brachial valve.

## TYPE SPECIMENS (measurements in mm.)

		Length	Width
HOLOTYPE.	External and internal moulds of brachial valve (BB.30574a-b) . . . . .	15.3	21.3 (distorted)
PARATYPES.	External and internal moulds of pedicle valve (BB.30575a-b) . . . . .	—	—
	External and internal moulds of brachial valve (BB.30576a-b) . . . . .	15.5	18.0 (est.)

TYPE HORIZON AND LOCALITY. Treiorwerth Formation, sandstones 300 yds. south-east of Ffynnon-y-mab, Trefor. N.G.R. 36247950.

DISCUSSION. In addition to bearing a frill, the new species shows detail differences from the described species of *Inversella*. *I. perundosa* Öpik from the Expansus-schiefer, *D. hirundo* zone (Öpik 1939 : 128, 142, Pl. 5, fig. 6) is the closest species, but has a prominent broad median costella.

## Family LEPTESTIIDAE Öpik 1933

## Subfamily LEPTESTIINAE Öpik 1933

## Genus PALAEOSTROPHOMENA Høltedahl 1916

*Palaeostrophomena* sp.

(Pl. 9, figs. 2, 4-5)

## FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal and external moulds of pedicle valve (BB.30579a-b) . . . . .	7.6	—
Internal mould of brachial valve (BB.30580) . . . . .	—	—

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. The pedicle valve is subquadrate, and gently convex. The ornament consists of fine costellae, divided into sectors each containing five to seven costellae separated by stronger costellae numbering about thirty. Internally there appear to be no dental lamellae, other details have been obliterated. The brachial valve shows the cardinalia, the cardinal process is a rounded mass (as preserved) passing into a median septum, the sockets and accessory sockets are conspicuous.

The specimens agree in all visible details with *P. magnifica* Williams, but the form of the ventral muscle scars, one of the diagnostic features of that species, is not visible in the Llanbabo specimens.

*Palaeostrophomena* (?) sp.

(Pl. 9, fig. 1)

FIGURED SPECIMEN (measurements in mm.)

	Length	Width
Exterior of pedicle(?) valve (BB.30581a-b) . . .	11.7	24.0 (est.)

HORIZON AND LOCALITY. Garn Formation, limestone blocks in breccia beds, Porth Padrig, Mynachdy. N.G.R. 30539279.

DISCUSSION. The valve is semicircular and gently convex. The posterior margin forms a slight angle at the umbo, the cardinal angles are acute, produced into small wings, and the lateral and anterior margins evenly curved. The ornament is of fine parvicostellae, separated into sectors containing sixteen in each by sharp accentuated costellae, about twelve in number in the whole valve, all the costellae arising by implantation. The surface of the valve is wrinkled along the posterior margin by radial rugae, which are more faintly developed over the whole surface.

The valve cannot be closely compared with *Palaeostrophomena* sp., as the interior is not exposed, but it agrees with the genus in exterior details. The closest species is *P. magnifica* Williams, though the number of parvicostellae in each sector is different. It could also belong to *Glyptambonites* Cooper, in which the pedicle valve has the same outline, convexity and ornament.

Family **LEPTELLINIDAE** Ulrich & Cooper 1936Subfamily **LEPTESTIININAE** Havlíček 1961Genus **LEPTESTIINA** Havlíček 1952*Leptestiina derfelensis* (Jones)

(Pl. 9, figs. 7-9)

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal mould of pedicle valve (BB.30577) . . .	4.8	—
Internal mould of brachial valve (BB.30578) . . .	—	—

HORIZON AND LOCALITY. Tandinas Shales, by the track 50 yds. west of Tandinas quarry, Careg-onen. N.G.R. 58248187.

DISCUSSION. Both valves show the internal characters well, particularly the brachial valve, in which the cardinalia and the lophophore platform are perfectly preserved. The papillae are not visible in the pedicle valve.

Genus **BILOBIA** Cooper 1956*Bilobia* aff. *musca* (Öpik 1930)

(Pl. 9, figs. 10-13)

DESCRIPTION. Triangular *Bilobia* with rounded cardinal angles and an anterior tongue, four-fifths as long as wide; the brachial valve evenly concave and the

pedicle valve slightly carinate with flattened flanks; teeth double, the posterolateral pair the larger; dental lamellae divergent, continuous with a raised rim to the muscle scars which is indented medianly in a right angle; diductor scars large and flabellate with small auxiliary lobes under the teeth, possibly just meeting anterior to the adductor scars and extending one-third the length of the valve; *vascula media* converging anteriorly from the ends of the diductor scars; dorsal lophophore platform prominent, one-half the length of the valve, elevated and free anteriorly, markedly bilobed with each lobe rounded.

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal mould of pedicle valve (BB.30582) . . . . .	10·3	10·6
Internal mould of brachial valve (BB.30583) . . . . .	—	—

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, 180 yds. east of Fferam-uchaf, Llanbabo. N.G.R. 36548673.

DISCUSSION. The pedicle valve is very similar to that of *Bilobia musca* (Öpik) in the general shape, the form of the teeth, and the muscle scars. In the brachial valve the lophophore platform has similar rounded anterior lobes. None of the specimens shows the cardinalia, and there are no external moulds well enough preserved to show the ornament.

Family **SOWERBYELLIDAE** Öpik 1930

Subfamily **SOWERBYELLINAE** Öpik 1930

Genus **EOPLECTODONTA** Kozłowski 1929

*Eoplectodonta lenis* Williams

(Pl. 9, figs. 14-18)

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal and external moulds of pedicle valve (BB.30584a-b) . . . . .	—	—
Internal and external moulds of brachial valve (BB.30585a-b) . . . . .	5·7	—
External mould of brachial valve with interarea of pedicle valve (BB.30586) . . . . .	—	—

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, Church Quarry, Llanbabo. N.G.R. 37758672.

DISCUSSION. The interior of the pedicle valve conforms to that of *E. lenis* from the Derfel Limestone, though the denticles are only poorly seen on the right side. The dorsal muscle scars are raised on low platforms, and are flabellate in form with one pair outside the other. The median and submedian septa are almost parallel, and between the scars are distinct depressions running their full length.

Subfamily **PTYCHOGLYPTINAE** Cooper 1956Genus **PTYCHOGLYPTUS** Willard 1928*Ptychoglyptus* sp.

(Pl. 10, figs. 1-2)

**DESCRIPTION.** Pedicle valve semicircular, slightly alate, gently convex; brachial valve concave medianly with flattened wings; ornament divided into sectors by sharp accentuated costae and costellae, 8 at the margin of valve 4 mm. long, possibly three primary, the others arising about 1.5 mm. from the umbo; between are fine parvicostellae, too poorly preserved to be counted; concentric ornament of prominent rugae, faint at less than 2mm. from the umbo, slightly asymmetrical in cross section, steeper towards the umbo; divided into sectors by the sharp costellae which they do not cross or fold, in the median part of the valves alternating between them, laterally tending to coincide across them, bent convex to the umbo; fine concentric growth lines follow the rugae, hence the valve margin is scalloped.

**FIGURED SPECIMENS** (measurements in mm.)

	Length	Width
Exterior of pedicle valve (BB.30590) . . . . .	4.4	—
Exterior of brachial valve (BB.30589) . . . . .	—	—

**HORIZON AND LOCALITY.** Garn Formation, limestone blocks in breccia beds, Porth Padrig, Mynachdy. N.G.R. 30539279.

**DISCUSSION.** The valves are all small, none being above 5 mm. long; since most described members of the genus are up to four times this length it is possible that these are all young specimens, not affording adequate material upon which to erect a new species. *Ptychoglyptus kindlei* Cooper (1956 : 816) appears similar, but grows to a much larger size and develops a geniculation. *P. virginiensis* Willard (Cooper 1956 : 818) is also similar though the rugae seem to become prominent at an earlier growth stage. *P. valdari* (Spjeldnaes 1957 : 58; Williams 1962 : 194) has rugae with both faces sloping anteriorly, with the posterior face undercut, and this is also true of *P. cf. valdari* from Girvan (Williams 1962 : 194). *P. cf. virginiensis*, also from Girvan (Williams 1962 : 193), has similar rugae and costae, and is Caradoc in age.

Subfamily **AEGIROMENINAE** Havlíček 1961Genus **SERICOIDEA** Lindström 1953*Sericoidea abdita* Williams

(Pl. 9, figs. 3, 6)

**FIGURED SPECIMENS** (measurements in mm.)

	Length	Width
Interior of brachial valve (BB.30587) . . . . .	1.7	—
Interior mould of brachial valve with shell material adhering (BB.30588) . . . . .	—	—



HORIZON AND LOCALITY. Tandinas shales, on the shore by the powerhouse 100 yds. west of the pier, Careg-onen. N.G.R. 58208193.

DISCUSSION. Specimen BB.30587 shows the pattern of septules characteristic of this species, three pairs of lateral septules and a narrow, more prominent median septule. BB.30588 shows the cardinalia but is not complete enough to show the septules.

Superfamily **STROPHOMENACEA** King 1846

Family **LEPTAENIDAE** Hall & Clarke 1892

Genus **LEPTAENA** Dalman 1828

*Leptaena* sp.

(Pl. 10, figs. 3-6)

DESCRIPTION. Outline semicircular, slightly auriculate; pedicle valve with concave visceral disc bounded by a sharply raised ridge passing to a sharp geniculation; interarea apace line, extending the width of the valve and about one-fifteenth as long as wide, delthyrium enclosing an angle of about  $135^\circ$ , open, pseudodeltidium not observed; brachial valve with flat visceral disc, bounded by rounded depression before the geniculation; interarea narrower than on the pedicle valve; notothyrium covered by a conspicuous convex chilidium with a median depression; interior of pedicle valve with teeth as narrow outgrowths from the hinge-line, elongated parallel to it, dental lamellae not seen, muscle scars elliptical in outline, with lanceolate adductor scars enclosed by diductors, the latter separated by a septum anteriorly; brachial interior with bilobed cardinal process tapering forwards to a point, the outer edges parallel and the inner ones diverging at  $60^\circ$ , sockets bounded by vague ridges forming the posterior edge to the muscle scars and uniting with a low median ridge to produce an anchor-like structure, with the median ridge passing into a short sharp median septum just before the edge of the disc, which is raised and crossed at intervals by radial grooves.

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal mould of pedicle valve (BB.30591) . . .	10.3	19.6 (est.)
Internal mould of brachial valve (BB.30592) . . .	—	—
Internal mould of brachial valve (BB.30593) . . .	—	—

HORIZON AND LOCALITY. Llanbabo Formation, Llanbabo Church Grits, 180 yds. east of Fferam-uchaf, Llanbabo. N.G.R. 36548673.

DISCUSSION. The material compares well with that from the Derfel Limestone (Whittington & Williams 1955 : 419, pl. 39, figs. 86-90). There is no septum preserved between the lobes of the cardinal process in the Angelsey specimens, and their exteriors are unknown.

Genus *DACTYLOGONIA* Ulrich & Cooper 1942*Dactylogonia* sp.

(P. 10, figs. 7-8)

DESCRIPTION. Brachial valve incomplete, broken along a growth line, possibly along a line of geniculation; slightly concave in longitudinal view, almost plane in anterior view; outline semi-circular, slightly alate, hinge-line straight, the greatest width; interarea very short, wide, anacline, notothyrium apparently lacking a chilidial cover; ornament of very faint concentric rugae, developing at about 3 mm. from the umbo, costellae if present too fine to be preserved; cardinal process short, bilobed, uniting with a low median ridge that bifurcates anteriorly; socket ridges diverging at  $110^\circ$  to each other, adpressed to the valve surface, bounding sockets which are not raised above the general interior; muscle scars bounded by a series of septa, two prominent sub-median septa parallel to each other becoming thickened and diverging at their posterior ends, separated by a slot from low thick diverging septa, which are separated from the socket ridges by a narrow depression; anterior ends of the sub-median septa separated by two triangular raised areas, between which is a thin median septum; inner surface outside the septa covered by a series of coarse pustules.

FIGURED SPECIMEN. Internal and external moulds of an incomplete brachial valve (BB.30596a-b).

HORIZON AND LOCALITY. Nantannog Formation, fine sandstones and shales 190 yds. south-east of Fferam-uchaf, Llanbabo. N.G.R. 36518657.

DISCUSSION. Without more material it is impossible to place this specimen more exactly. The pattern of septa recalls those of *Dactylogonia* (cf. Cooper 1956 : pl. 225, fig. 4), though the septa here are nearer the socket ridges, and are separated only by narrow slots. The three pairs of raised areas together form a rim, locating within it the visceral mass of the animal. The slots between the septa were probably for the passage of the various *vascula*, the *vascula media* between the anterior pair, and the *vascula myaria* posterior to the long prominent pair. The inner margins of the two pairs of septa slope obliquely inwards, and are probably the seats of attachment of the adductor muscle scars.

?*Dactylogonia* sp. has been described by MacGregor (1961 : 204) from the upper Llandeilo of the Berwyn mountains. His specimen does not greatly resemble that described above, the septa being weakly developed, the cardinal process large, and the pustules less distinct and drawn out radially.

Genus *KIAEROMENA* Spjeldnaes 1957*Kiaeromena* (?) sp.

(Pl. 10, figs. 9, 10)

FIGURED SPECIMENS. Exterior of incomplete pedicle(?) valve (BB.30594). Exterior of incomplete brachial(?) valve (BB.30595).

HORIZON AND LOCALITY. Garn Formation, limestone blocks in breccia bed, Porth Padrig, Mynachdy. N.G.R. 30539279.

DISCUSSION. The valves are semicircular, slightly alate and geniculate, and as neither the hinge-lines and interareas nor the interiors are preserved the valves have been determined on their transverse profile and ornament. The pedicle valve is convex, with the disc slightly carinate along the midline, the brachial valve with a slightly concave disc. The ornament on both valves is of fine parvicostellae, approximately ten per mm. on the valve margins, divided into sectors by stronger costellae, of which six arise near the umbo and fifteen are present at the margin of a valve about 9 mm. long. Both types of ribs arise by implantation. There are no rugae on the disc.

Order PENTAMERIDA Schuchert & Cooper 1931  
 Suborder SYNTROPHIIDINA Ulrich & Cooper 1936  
 Superfamily **PORAMBONITACEA** Davidson 1853  
 Family **HUENELLIDAE** Schuchert & Cooper 1931  
 Subfamily **RECTOTROPHIINAE** nov.

Globular huenellids with parallel dental lamellae, and with parallel supporting plates in the brachial valve, without cardinal process.

Genus **RECTOTROPHIA** nov.

DIAGNOSIS. Globular subtriangular biconvex shells with deep pedicle valve and less convex brachial valve, rectimarginate commissure and narrow hinge-line; ornament unknown.

Ventral interior with parallel dental lamellae, the muscle scars confined between them and elevated on a low pseudospondylium.

Dorsal interior with parallel, receding supporting plates, without a cardinal process, adductor muscle scars hexagonal in outline, expanding anteriorly from the anterior ends of the supporting plates.

TYPE SPECIES. *Rectotrophia globularis* sp. nov. from the Treiorwerth Formation.

DISCUSSION. The Heunellidae, into which the new genus falls, at present comprises two subfamilies, the Huenellinae, without a cardinal process, and the Mesonomiinae, with a rudimentary cardinal process and recumbent brachiophore plates. Both families are also characterized by the development of a fold and sulcus, and by having non-parallel supporting plates. The disposition of the supporting plates in the new genus, together with the shape of the valves and the absence of fold or sulcus, necessitate the erection of a new sub-family.

***Rectotrophia globularis*** gen. et sp. nov.

(Pl. 10, figs. 11-17)

DIAGNOSIS. As for genus.

## TYPE SPECIMENS (measurements in mm.)

		Length	Width
HOLOTYPE.	Internal mould of pedicle valve (Af. 1436)	6.7	7.0
PARATYPES.	Internal mould of brachial valve (Af. 1436)	—	6.7 (est.)
	Internal mould of brachial valve (Af. 1442)	6.7	5.7

TYPE HORIZON AND LOCALITY. Treiorwerth Formation, sandstones 300 yds. south-east of Ffynnon-y-mab, Trefor. N.G.R. 36247950.

DISCUSSION. The genus is known only from a few internal moulds, from Greenly's collection, the writer having found no well-preserved specimens. As a result no mean estimates of proportions can be included in a precise specific diagnosis. The holotype is 2.8 mm. thick, and the dental lamellae are 1.7 mm. apart. In the first paratype (Af. 1436) the supporting plates are 1.9 mm. apart, in the second they are 1.5 mm. apart and the adductor muscle scars are 1.9 mm. long.

Family **PORAMBONITIDAE** Davidson 1853Genus **PORAMBONITES** Pander 1830*Porambonites* (s.s.) sp.

(Pl. 11, figs. 1-6, 8)

## FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal and external moulds of pedicle valve (BB.30598a-b)	18.0	—
Internal and external moulds of brachial valve (BB.30599a-b)	20.5	23.2
Internal mould of brachial valve (BB.30600)	13.3	12.5

HORIZON AND LOCALITY. Treiorwerth Formation, sandstones 300 yds. south-east of Ffynnon-y-mab, Trefor. N.G.R. 36247950.

DISCUSSION. The specimens are all disarticulated, incomplete, and have suffered some distortion. Since the species of *Porambonites* are to a large extent based on external form it is not possible to make a close comparison with any described species. In addition the fold and sulcus do not develop until the shell is well grown, and of the figured specimens only BB.30599 has a good fold.

The valves are roughly circular in shape, and so do not belong to the subgenus *Equirostra* (*Isorhynchus*). The pedicle valve is lenticular, without a swollen umbo, the brachial valve more convex. The internal features of both valves are well preserved, but only the dorsal muscle scars are visible. The adductor scars are bluntly wedge-shaped and form an arc lying anterior to the ends of the supporting plates. The diductor scars are four(?) in number forming a narrower central pair flanked by two wider scars.

Allied species, from the lower Ordovician of the Baltic are *P. bröggeri* Lamansky, *P. altus* Pander and *P. planus* Pander,



Family **CAMERELLIDAE** Hall & Clarke 1894  
 Subfamily **CAMERELLINAE** Hall & Clarke 1894  
 Genus **CAMERELLA** Billings 1859

*Camerella* sp.

(Pl. II, figs. 7, 9-11)

FIGURED SPECIMEN. Complete shell (BB.30597), length 4.8 mm., width 5.1 mm., thickness 2.9 mm.

HORIZON AND LOCALITY. Garn Formation, limestone blocks in breccia beds, Porth Padrig, Mynachdy. N.G.R. 30539279.

DISCUSSION. The figured specimen is the only complete one known, the others being only fragments of smaller valves. It is sub-triangular, slightly wider than long, with both valves approximately equally convex. The dorsal fold at the anterior margin is two-thirds the width of the valve, and originates at 2.6 mm. anterior to the umbo. It comprises two bounding costae, separated by a shallow depression which corresponds to a low costa or fold in the pedicle valve. The ventral sulcus is flanked by a pair of subangular costae. A few growth lines on the pedicle valve show the outline to have been sub-circular until the fold and sulcus started to develop.

The majority of described species of *Camerella* have three or more costae developed on the fold, all the costae appearing at the same time, that is, when the fold starts to appear. *C. unicostata* (Cooper 1956 : 583, pl. 113, B, figs. 6-9) has a similar development of costae on the fold and sulcus, but has more costae on the flanks, and, at the same size, seems to be more tumid and is suboval in outline.

Suborder PENTAMERIDINA Schuchert & Cooper 1931

Superfamily **PENTAMERACEA** M'Coy 1844

Family **PARALLELELASMATIDAE** Cooper 1956

Genus **METACAMERELLA** Reed 1917

*Metacamerella* cf. *balcletchiensis* (Davidson)

(Pl. II, figs. 12-14)

1919 *Camarella?* [cf. *Stricklandinia? balcletchiensis* (Dav.)]; Matley in Greenly : 478.

FIGURED SPECIMEN. Complete shell (Af.1590) length 21.1 mm., width 20.0 mm., thickness 15.0 mm.

HORIZON AND LOCALITY. Garn Formation, limestone blocks in breccia beds, Porth Padrig, Mynachdy. N.G.R. 30539279.

DISCUSSION. The only specimen so far found, a complete shell from Greenly's collection, is very similar to the Girvan species (Williams 1962 : 232). The outline is comparable, with 'false interareas' extending just over half the length of the shell, and, so far as can be seen, a very low fold on the antero-median part of the brachial valve. The ornament is also very similar, consisting of about six low rounded



costae, with a wavelength of 2 mm. at 13 mm. from the umbo. The interior details are not seen and hence cannot be compared with *M. balclethiensis*.

Order uncertain  
(Pl. 10, figs. 18-24)

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal and external moulds of pedicle valve (BB.55792a-b) . . . . .	18.9	18.6
Internal and external moulds of brachial valve (BB.55791a-b) . . . . .	—	20.5

HORIZON AND LOCALITY. Torllwyn Formation, sandstone 50 ft. above the base of the succession on the north side of the faulted syncline, 45 yds. north of Ogof Gynfor, Llanbadrig. N.G.R. 37859490.

DISCUSSION. The valves are rostrate and convex, roughly circular in outline. The pedicle valve bears a strongly marked sulcus with a flattish floor, flanked by angular folds, and has a narrow curved interarea. The delthyrium is apparently open. The brachial valve bears a corresponding fold, and both valves are costellate, with flat-topped costellae interspersed with narrow interspaces. In the ventral interior the dental lamellae are almost parallel, the muscle scars raised on a wad of callus extending anterior to the lamellae on a pseudospondylium which is rounded at its anterior end. The dorsal cardinalia are not fully preserved, though supporting plates diverge to the floor of the valve.

The external shape and ornament of the valves suggests the syntrophiid *Rhystrophia*, but the internal structures differ considerably, and the specimens may well belong in the Orthida.

V. SYSTEMATIC DESCRIPTION OF THE TRILOBITA

Family **ASAPHIDAE** Burmeister 1843

Subfamily **OGYGIOCARIDINAE** Raymond 1937

Genus **OGYGIOCARIS** Angelin 1854

***Ogygiocaris selwynii*** (Salter)

(Pl. 12, figs. 1-2, 5-6)

1919 *Ogygia selwyni* Salter; *Lake in Greenly* : 442, 446.

DESCRIPTION. Cranidium quadrilateral, wider than long, evenly convex (*tr.*). Glabella almost as long as cranidium, sides almost parallel but slightly constricted opposite the eyes, anterior margin semicircular; evenly convex (*tr.*), slightly convex (*longit.*) with a dome-shaped anterior lobe; glabellar furrows almost obsolete; one pair faintly impressed midway along the glabella. Axial furrows weak, ending in shallow hypostomal pits; occipital ring reduced to a pair of triangular raised portions pointing inwards to the tubercle, with a narrow articulating ring formed by a faint furrow behind the triangular facets (following Harrington & Leanza's interpretation, 1957 : 177). Preglabellar field absent. Fixigenae triangular shaped

areas behind the eyes. Posterior border sloping slightly backwards; posterior border furrow broad and shallow, opposite the occipital ring adaxially. Eyes semicircular, very close to and centred on the transverse midline of the glabella. Facial suture isoteliform, with the anterior branches widely divergent in front of the eyes, meeting in an even curve without any apparent acumination; posterior branches oblique backwards and outwards, sigmoidal.

Pygidium transverse, one and one-half times as wide as long; anterior margin convex forwards, postero-lateral margins convex, with the greatest curvature across the midline. Axis tapering backwards, not extending onto the posterior border and with the end rounded; probably with eight or more axial rings; narrow (*longit.*) articulating half ring. Marked anterior border. Pleural fields with pleural furrows marking more than four segments, each bearing oblique ridges near their outer ends. Border of uniform width, one-fifth the length of the whole pygidium, concave but with a convex ridge against the pleural fields. Doublure convex ventrally and of the same width as the border.

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal mould of cranidium (Af.842) . . .	distorted	
Internal mould of cranidium (Af.823) . . .	31.5	36.0
Internal mould of pygidium (Af.820) . . .	37.5	54.0 (est.)
Internal mould of pygidium (Af.821) . . .	—	—

HORIZON AND LOCALITY. Carmel Formation, sandstones. Af.820–823 from the scarp west of Bryn Gollen Uchaf (Bryn Gwallen of Greenly), N.G.R. 40558380; Af.842 from quarry 400 yds. north-north-west of Bryn Gollen Uchaf, N.G.R. 40508425.

DISCUSSION. The cranidia correspond closely with that of *O. selwynii* as described by Whittard (1964 : 233) though it is difficult to recognize the glabellar furrows. In particular the anterior portions of the facial sutures diverge at the same angle, and their course close to the median suture is also similar.

Af.820, the internal mould of the pygidium differs in that the posterior border is more strongly curved across the midline than laterally, whereas the reverse is true of *O. selwynii* (Whittard 1964 : 235). Af.821 shows oblique ridges in addition to the pleural furrows.

Family **THYSANOPELTIDAE** Hawle & Corda 1847

Genus **PROTOBRONTEUS** Šnajdr 1960

***Protobronteus greenlyi*** sp. nov.

(Pl. 12, figs. 3–4, 7)

1919 *Iliaenus caecus* Holm (*partim*); Lake in Greenly : 478.

DIAGNOSIS. A species of *Protobronteus* with no inner anterior border furrow, and an ornament of coarse terrace lines without intervening pits, transverse in alignment over the anterior part of the fixigenae.

DESCRIPTION. Both cranidia incomplete, probably semicircular with truncated

corners. Glabella clavate, reaching to the anterior border, evenly convex (*sag.* and *tr.*); narrowest just behind the midline (*sag.*), just longer than wide; without glabellar furrows. Axial furrows convex inwards, well defined. Occipital ring not seen. Fixigenae incomplete, evenly convex (*long.*), palpebral lobe and course of facial suture not seen. Anterior border not separated from glabella mesially, but present in front of the fixigenae; anterior border furrow well defined, meeting the axial furrow in a right angle, and continuing a little way adaxially to define the anterolateral corner of the glabella. Ornament of coarse terrace lines, averaging five to eight per 5 mm., becoming crowded together on the anterior border, transverse across the glabella, borders and anterior part of the fixigenae, not preserved elsewhere.

Librigena incomplete, triangular, convex (*long.*), with prominent anterolateral border furrow, no posterior border furrows. Eye lobe large, semicircular. Genal spine long, circular in cross-section. Ornament of distant terrace lines, diverging on either side of eye.

TYPE SPECIMENS (measurements in mm.)

		Length	Width
HOLOTYPE.	Incomplete cranidium (In.58291) . . .	28.8	—
PARATYPES.	Incomplete cranidium (In.58292) . . .	—	—
	Internal mould and interior of incomplete librigena (In.58293a-b) . . .	—	—

TYPE HORIZON AND LOCALITY. Garn Formation, limestone blocks in breccia beds, Porth Padrig, Mynachdy. N.G.R. 30539279.

DISCUSSION. *Protobronteus* was erected by Šnajdr (1960 : 245-246) to include only *Eobronteus reedi* Sinclair (1949 : 51-52). In this species, as in *P. greenlyi* the glabella is clavate, without any glabellar furrows, and coalesces with the anterior border. *E. curtus* Sinclair (1949 : 50-51) is very similar and could well be included in *Protobronteus* as the glabellar furrows are indistinct and the anterior border furrow fades out mesially.

*P. greenlyi* differs from both these species in that the inner anterior border furrow is absent (the cheek furrow of Sinclair 1949 : 51), and the ornament is differently developed. In *P. reedi* the terrace lines are longitudinal between the two border furrows, and in *E. curtus* they are not developed in the same place, only coarse punctae being present.

Family **ILLAENIDAE** Hawle & Corda 1847

Subfamily **ILLAENINAE** Hawle & Corda 1847

Genus **ILLAENUS** Dalman 1827

*Illaeus* sp.

(Pl. 12, figs. 8-13, 15)

1919 *Illaeus caecus* Holm (*partim*); Lake in Greenly : 478.

DESCRIPTION. Cranidium quadrangular, evenly convex (*tr.*), longitudinal convexity strong posteriorly, weak anteriorly. Glabella short and wide, with slight

independent convexity (*tr.*), two-thirds the width of the cranium. Axial furrows curve inwards for two-thirds of their length, and end in an outwards curve. Palpebral lobes one-third the length of the cranium, situated less than their own length from the posterior margin. Posterior branches of the facial sutures short, running directly backwards, anterior branches slightly divergent. Dorsal surface of cranium smooth.

Pygidium parabolic, the anterior margin slightly convex forwards, width four-thirds the length, convex, the inner pleural fields gently convex and the margins deflected at about  $45^\circ$ . Axis short, sub-triangular, with independent convexity (*tr.*), four-tenths the width of the pygidium. Axial furrows shallow posteriorly, meeting at about  $60^\circ$ . Short (*long.*) articulating half ring. Pleural fields with anterior borders slightly swollen, marked off by shallow depressions. Articulating facets sharply bevelled, with terrace lines extending beyond them. Rest of dorsal surface finely pitted. Doublure close to the dorsal shield, convex ventrally at its outer margin, almost half the length (*sag.*) and one-tenth the width of pygidium at anterior margin. Inner margin commencing near midline of facet (*tr.*), swinging in a curve gradually decreasing in radius to the midline of the pygidium, where a forward pointing cusp is found. Ventrally deflected median ridge strongly marked. Doublure bears terrace lines running parallel to its margins about 0.7 mm. apart.

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Cranidium (In. 58294)	—	9.9
Pygidium (In. 58295)	23.7	32.7
Pygidium (In. 58296)	22.6	33.5

DISCUSSION. The species resembles *Iliaenus revaliensis* (Holm 1886 : 87-92, pl. 2, figs. 1-10) particularly in the shape and other features of the pygidium. The axis is similar, and the inner margin of the doublure has a forward pointing cusp at the midline. The cranium is poorly preserved, and may possibly be a crushed and distorted cranium of *Stenopareia* cf. *linnarssoni* (Holm), but the glabella is relatively wider, the palpebral lobes are much larger, and the anterior margin seems to be sharply truncated.

Genus **STENOPAREIA** Holm 1886

***Stenopareia* cf. *linnarssoni*** (Holm)

(Pl. 12, figs. 14, 16-23)

1919 *Iliaenus caecus* Holm (*partim*); Lake in Greenly : 478)

DESCRIPTION. Cranium quadrangular, the frontal area domed, strongly and evenly convex (*long.* and *tr.*). Glabella with slight independent convexity (*tr.*), half the length of cranium. Two pairs of oval muscle scars between the axial furrows, the anterior pair indistinct. Axial furrows poorly defined on dorsal, but well defined on ventral surface, extending forwards half the length of cranium, widening in their anterior half to be well defined on the ventral surface. Palpebral lobes less than one fifth the length of cranium, less than their own length from



the posterior border. Posterior braches of facial suture short, straight, running diagonally outwards, anterior branches straight, converging slightly forwards. Glabella and fixigenae with smooth dorsal surfaces, frontal margin with faint terrace lines on the ventral surface.

Librigena twice as long as wide, tapering to a point anteriorly, with vertically deflected border present anteriorly. Genal angle very broadly rounded.

Rostral plate triangular, anterior margin gently convex outwards, the posterior margins concave rearwards, meeting in a central cusp with an angle of less than 90°. Ventral surface with terrace lines.

Pygidium semi-oval, just over half as long as wide, weakly convex except at the sides where almost vertically deflected. Axis one-third the anterior width, undefined posteriorly, evenly convex (*tr.*). Axial furrows shallow, only seen at anterior margin. Dorsal surface smooth. Articulating facets convex, almost vertical. Doublure lies close to the dorsal surface, with a faint median ridge, anterior margin monocuspid(?).

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Cranidium (In. 58297) . . . . .	15.5	18.6
Cranidium (In. 58298) . . . . .	—	14.6 (est.)
Librigena (In. 58299) . . . . .	19.7	—
Rostral plate (In. 58300) . . . . .	8.9	22.6
Pygidium (In. 58301) . . . . .	23.4	42.4 (est.)
Pygidium (In. 58302) . . . . .	13.5	22.5

HORIZON AND LOCALITY. Garn Formation, limestone blocks in breccia beds, Porth Padrig, Mynachdy. N.G.R. 30539279.

DISCUSSION. The cranidium is very similar to that of *Stenopareia linnarssoni* (*Illaenus linnarssoni* Holm *in* Warburg 1925 : 115-123, pl. 2, figs. 14-18). The glabellar proportions and the axial furrows are the same, with an anterior swelling of the furrows. The palpebral lobes are the same size and equally far back. The pygidia are approximately similar in proportion; the inner margin of the doublure is unknown, though it also has a ventrally deflected median furrow. The facets are narrow and rounded in both cases, but the axis is relatively narrower in the Anglesey specimens. *Stenopareia camladica* Whittard (1961 : 216-217, pl. 30, figs. 10-13) has a similar cranidium, but the axial furrows are poorly preserved, and the pygidium is differently proportioned in the Shropshire species.

Family **HARPIDAE** Hawle & Corda 1847

Genus **SELENOHARPES** Whittington 1950

*Selenoharpes* (?) sp.

(Pl. 13, figs. 1-2, 5-6)

DESCRIPTION. Outline of cephalon oval; greatest width probably behind the occipital ring.

Glabella tapering forwards, width at its base seven-ninths of its length, rounded



anteriorly; sharply convex and carinate, in height equal to its width; in lateral profile becoming vertical anteriorly. Basal lobes triangular, very vague, one-third the length of the glabella, marked by shallow furrows running inwards and backwards. Axial, preglabellar, and occipital furrows all shallow. Occipital ring one-ninth length of the glabella, bent up with it.

Pre-glabellar field one-third length of the glabella, sloping anteriorly. Eye tubercles prominent and elevated above the cheeks, opposite the anterior one-fifth of the glabella. Eye ridges broad, running directly inwards. Genal ridges fine, running outwards and backwards to the girder. Alae one-third the length of the glabella, depressed, marked by semicircular alar furrows. Cheek lobes bent down anterolaterally and laterally. Posterior border with sharply raised convex rim, continuous with a similar rim on the inward side of the prolongations. Cheek roll not separable from the cheeks. Brim equal in width anteriorly to the glabellar length, convex, with a row of prominent pits just inside the rim marking the inner edge of a downward bevel round the rim. Girder smooth, with prominent pits forming a single row on both sides; girder possibly meeting the internal prolongations. Glabella and alae smooth; preglabellar field and cheek lobes anterior and lateral to the eyes with radiating ridges with fine pits between them; on the rest of the cheeks and on the brim are similar fine pits but without ridges or arrangement.

FIGURED SPECIMEN. Incomplete cranidium (In. 58303).

HORIZON AND LOCALITY. Garn Formation, limestone blocks in breccia beds, Porth Padrig, Mynachdy. N.G.R. 30539279.

DISCUSSION. The two closest genera are *Selenoharpes* and *Aristoharpes*, the former of Middle Ordovician (post-Llandeilo) age and the latter of Llandovery age. In *Selenoharpes* the glabella tapers forwards, the eye ridges are prominent and genal ridges are present. In *Aristoharpes* the glabella is sub-parallel sided, eye ridges are weak and genal ridges absent. It also has much smaller alae than *Selenoharpes*, which are one-quarter the length of the glabella compared with one-half. There is thus some doubt as to where to place these specimens, which compare closely with *Selenoharpes*, except for the smaller alae, a difference that is probably trivial. The specimens are certainly not conspecific with the type species, *S. youngi* (Reed) from the lower Caradoc of Girvan, in which the brim is convex upwards.

Family **TRINUCLEIDAE** Hawle & Corda 1847

Subfamily **CRYPTOLITHINAE** Angelin 1854

Genus **BERGAMIA** Whittard 1955

*Bergamia* (?) sp.

(Pl. 13, figs. 3-4, 9, 13)

DESCRIPTION. Cephalon twice as broad as long. Glabella pyriform, swollen, tapering markedly posteriorly, second and third furrows fairly well marked, pit-like in form; well marked alae bounded laterally by deep furrows, ending laterally against the posterior border in well marked knobs; glabellar furrows not well marked

against the alae. Genae swollen, crossed by a ridge running obliquely back from the front of the glabella to the genal angle. Occipital ring very narrow, arched and convex posteriorly; posterior borders from a narrow sharp ridge posterior to a wide shallow furrow. Glabella and genae posterior to the ridge bear a strong reticulate pattern, becoming faint towards the front of the glabella. Fringe of uniform width throughout except at the genal angle; pits sunk in deep radial sulci; girder not seen in any of the specimens; sulci number eighteen on each side of the centre-line, with up to four pits in each; interradian sulci numbers i and ii present; some twin pits.

Thoracic segments not well preserved; axis strongly convex with axial rings convex posteriorly; pleural regions with strong oblique pleural furrows; pleural spines strong and directed posteriorly.

Pygidium over twice as wide as long, triangular in outline; axis tapers at  $30^\circ$  with at least five axial rings, well defined and strongly arched; pleural lobes divided by at least four faintly marked oblique interpleural furrows; anterolateral angles bevelled as an articulating facet; posterior margins with a broad border of uniform width, slightly raised over the centre-line.

FIGURED SPECIMENS. Counterpart moulds of cranium and pygidium (In. 58304a-b). Length of cranium (sag.) 3.4 mm., width 7.0 mm. Length of pygidium 1.7 mm., width 4.2 mm.

Counterpart moulds of complete dorsal carapace (In. 58305a-b). Length (sag.) 2.5 mm.

Ventral mould of dorsal carapace (In. 58306) Distorted.

HORIZON AND LOCALITY. Shales, *D. bifidus* zone, quarry 100 yds. north of Gwredog-uchaf farm, Rhodogeidio. N.G.R. 40488628.

DISCUSSION. The preservation of the specimens, in particular of the fringe, is not good enough to make a certain generic identification. However, the simplicity of the fringe suggests that the specimens belong to *Bergamia*, which ranges from the uppermost Arenig through the Llanvirn, and possibly into the Caradoc (Whittard 1955 : 31). The species resembles *B. rhodesi* Whittard (1955 : 32) in the arrangement of the pits on the fringe. The smallest specimen illustrated (Pl. 13, fig. 3) is a meraspid of probably degree two. There is little difference in characters from the larger specimens.

### Family **RAPHIOPHORIDAE** Angelin 1854

#### Genus **AMPYX** Dalman 1827

#### *Ampyx* sp. (1)

(Pl. 13, fig. 8)

1919 *Ampyx* cf. *domatus* (Angelin); Lake in Greenly : 446.

1955 *Ampyx* sp.; Whittard : 17.

FIGURED SPECIMEN. Cranium (Af. 824). Length 9.0 mm., width 12.4 mm.

HORIZON AND LOCALITY. Carmel Formation, sandstones on the escarpment 300 yds. west of Bryn Gollen Uchaf. N.G.R. 40558380.

DISCUSSION. This specimen remains the only one collected from the basal grits, and there is nothing that can be added to Whittard's opinion that it probably belongs to an undescribed species.

*Ampyx* sp. (2)

(Pl. 13, figs. 7, 10-12)

1919 *Ampyx nasutus* Dalman; Lake in Greenly : 433.

DESCRIPTION. Cranidium quadrilateral in outline, length four-tenths the width, the anterior border very well developed. Glabella pyriform, widest near the anterior end and broadly rounded in front, one-third to one-quarter the width of the cranidium in front, tapering to the occipital ring, exceptionally weakly swollen, overhanging only part of the preglabellar field. One pair of glabellar furrows almost isolating long narrow lobes, the furrows running back parallel to the axial furrows, starting just anterior to the transverse midline of the glabella; alae (cf. Whittard 1955 : 15) crescentic, starting anterior to the glabellar furrows and extending backwards to meet the posterior border furrow, axial and alar furrows faint; glabellar spine at least half as long as the cephalon, circular in cross section, possibly concave dorsally. Fixigenae triangular, gently convex. Facial suture runs in a gentle sigmoidal curve convex outwards as it crosses the posterior border, convex inwards forwards of this and again convex outwards in its anterior third. Occipital ring narrow, occipital furrow shallow, both convex backwards. Posterior border furrow broad and shallow, running obliquely outwards and backwards, but sweeping forwards again near the genal angle; posterior border widening laterally. Pre-glabellar field comparatively long, about one-sixth the length of the cephalon, flattened.

Thorax of six segments, broad and flat. Axis convex, axial rings each with a shallow groove defining small lobes at each side. Pleurae parallel-sided, each with an oblique furrow curved forward at the tip, sharply deflected ventrally at prominent fulcral processes which appear as tubercles. First or macro-pleurae longer than the others with outer margins not deflected but sloping backwards and out to the fulcrum. Other pleurae with blunt terminations.

Pygidium triangular, twice as wide as long. Anterior margin straight, posterolateral borders slightly convex, deflected, with terrace lines parallel to the margins. Axis convex, with narrow articulating half-ring, tapering from one-fifth the width of the pygidium anteriorly to a point at the posterior end, occasionally a few axial rings present. Pleural lobes smooth, except for strongly developed anterior borders, marked off by sharp furrows running obliquely backwards and outwards, becoming concave forwards laterally to meet the anterolateral angle of the pygidium. Prominent fulcral tubercle at the inner end of the articulating facet.

## FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal and external moulds of cranidium (In. 58307a-b)	16.0	35.6 (est.)
External mould of cranidium (In. 58308)	—	—
Internal mould of thoracic segments and pygidium (Af. 3653)	16.3	19.3
External mould of pygidium (In. 58309)	7.0	16.8 (est.)

HORIZON AND LOCALITY. Tandinas shales, by the track leading down to the quarry, and on the shore behind the power house, at Tandinas quarry, Careg-onen. N.G.R. 58248187.

DISCUSSION. The species is similar to *A. linleyensis* Whittard of the Shelve area (*D. bifidus* zone), but differs in having a short, weakly swollen glabella, a pre-glabellar field, and having terrace lines on the pygidium. *A. salteri* Hicks (*D. extensus* zone?) also has terrace lines to the pygidium, but lacks a pre-glabellar field.

Family **CHEIRURIDAE** Salter 1864

Subfamily **CHEIRURINAE** Salter 1864

Genus **CERAURINELLA** Cooper 1953

*Ceraurinella* sp.

(Pl. 13, figs. 14-22)

DESCRIPTION. Cranidium roughly triangular in outline, broader than long. Glabella evenly convex (*tr.*), gently convex (*sag.*) becoming more convex along the anterior lobe. Length equal to the maximum width, the latter across the anterior lobe, sides slightly tapering towards the occipital ring, front margin convex forwards. Three pairs of narrow well marked glabellar furrows; 1p inclined obliquely backwards, bent back to join the occipital furrow nearer the midline than the axial furrows; 2p and 3p parallel to each other, curving obliquely backwards and crossing one-third the width of the glabella (*tr.*). Basal lobes with independent convexity, one and a half times the length (*exsag.*) of the second and third lobes; the latter subequal in length without independent convexity. Occipital furrow not well seen, shallow. Fixigenae triangular convex, eye lobe on the highest part, opposite and close to the second glabellar lobe, equal in length to that lobe (*exsag.*). Anterior part of fixigenae parallel sided, anterior branch of facial suture running in to meet the axial furrows just in front of 3p glabellar furrows. Posterior branch of facial suture runs transversely out from the eye, and curves round to meet the anterolateral border of the cranidium. Posterior border furrows deep and wide, bending sharply forwards to meet the lateral border furrow. Posterior border widening laterally towards genal spine, length of latter unknown. Glabella and borders smooth, fixigenae coarsely tuberculate. Librigenae unknown.

Hypostome slightly longer (*sag.*) than maximum width (*tr.*) across anterior wings,



tapering backwards to a width at the posterior border half the maximum. Median body convex (*sag.* and *tr.*) widest in front of anterior wings. Anterior, lateral and posterior border furrows broad and shallow. Middle furrows faint, running in from opposite shoulders to end in shallow pits. Posterior lobe crescentic, independently convex where marked off by the middle furrows. No anterior border medianly. Anterior wing slopes steeply dorsoposteriorly, tip narrow and spine-like. Lateral border commences opposite anterior wing, widens rapidly to prominent and sharp shoulder (in ventral view) which is just less than half the way back (*exsag.*) from the anterior border, continuous with the posterior border. Short denticle or spine on the posterolateral corners, posterior border straight. Posterior wing not seen. Entire surface smooth.

Thorax of unknown number of segments. Axis arched, most sharply convex over the midline, length (*sag.*) one-fifth the width, width one-quarter that of the whole segment. Anterior margin convex forwards over the midline, concave forwards laterally above the apodemes, which are deflected ventrally (no articulating half-ring seen). Inner part of pleura horizontal, divided in two by a furrow parallel to the axial furrow, the inner part being one-third the width of the whole, and crossed by a diagonal furrow, the outer part bent abruptly ventrally and forming a gradually tapering pleural spine. No ornament on the segments.

Pygidium poorly preserved. Convex axis with four axial rings, or three axial rings and an articulating half ring. Margin not preserved, except for one long tapering spine probably commencing opposite the second axial ring and curving backwards towards its tip. No ornament present.

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Incomplete glabella (In.58310) . . . . .	—	8.7
Incomplete glabella (In.58311) . . . . .	—	10.3
Incomplete cranium (In.58312) . . . . .	13.6	—
Hypostome (In.58313) . . . . .	—	—
Hypostome (In.58314) . . . . .	7.9	5.4
Hypostome (In.58315) . . . . .	—	9.1
Thoracic segment (In.58316) . . . . .	—	—
Thoracic segment (In.58317) . . . . .	—	—
Incomplete pygidium (In.58318) . . . . .	—	—

HORIZON AND LOCALITY. Garn Formation, limestone blocks in breccia beds, Porth Padrig, Mynachdy. N.G.R. 30539279.

DISCUSSION. The specimens are assigned to *Ceraurinella* since the eyes are opposite the 2p lobes and near the glabella, the genal spines though not complete are short, the pygidium has the long spines typical of that genus (and *Ceraurus*), and the thoracic segments and hypostome also are of the same type. The species described by Cooper (1953 : 29-30) and by Whittington & Evitt (1953 : 62-70) differ in their ornament, which is more pervasive, and possibly also in other minor details. None of the species of *Ceraurus* (Raymond & Barton 1913; Barton 1913)



corresponds. *Ceraurinėlla?* sp. has been recorded by Whittington from the Derfel limestone (*in* Whittington & Williams 1955 : 422-423, pl. 40, figs. 102, 107 and 111), but the two species are not the same, as in his figures the eyes, not preserved, cannot have been farther back than opposite the 3p glabellar lobes, and the 3p lobes seem to be longer (*sag.*) than the others.

Subfamily **SPHAEREXOCHINAE** Öpik 1937

Genus **SPHAEREXOCHUS** Beyrich 1845

*Sphaerexochus* sp.

(Pl. 14, figs. 1-2)

DESCRIPTION. Cranium only preserved, distorted by flattening, crescent shaped in outline, original convexity not known. Glabella subcircular to pentagonal in outline, widest opposite the second glabellar furrow (2p). Occipital ring narrower than the glabella at its maximum, one-eighth of glabella length (*sag.*), convex, posterior margin concave backwards. Occipital furrow broad and deep, uniformly curved throughout. First glabellar furrows (1p) transverse with a gently concave backwards curve, curving sharply at their inward ends towards the occipital furrow, running to meet it in another gentle curve convex sagittally. The first lateral glabellar lobes isolated, subquadrate in outline, possibly without independent convexity, four-ninths the length of the glabella (*sag.*), approximately two-ninths its width. Second glabellar furrow (preserved only on one side) very short, straight. Second glabellar lobe one-half length of the first. No third glabellar lobes or furrows. Anterior border not preserved. Fixigenae small, triangular, convex. Palpebral lobe very narrow, opposite to 1p furrow, two-thirds the length of the first lobes. Facial suture not seen forward of the eye. Posterior branch runs outwards and then backwards to meet the posterior border at right angles. Posterior border equal in width to the occipital ring at its inner end, widening towards the genal angle. Posterior border furrow concave forwards, dying out towards the genal angle.

FIGURED SPECIMEN (measurements in mm.)

	Length	Width
Cranidium (In. 58319)	6.0 ( <i>sag.</i> )	9.5

HORIZON AND LOCALITY. Tandinas shales, on the shore by the powerhouse, 100 yds. west of the pier, Careg-onen. N.G.R. 58208193.

DISCUSSION. The specimen differs from all described species of *Sphaerexochus* by having two pairs of lateral glabellar furrows. *S. bilobatus* (Whittard 1958 : 110) has only the basal pair developed, otherwise three pairs seem to be the rule. The preservation of the specimen has resulted in accentuation of the anterior furrow on one side, and its obliteration on the other. It is possible, though unlikely that a third pair of furrows may be present, but obliterated.

Family **PLIOMERIDAE** Raymond 1913

Subfamily **PLIOMERINAE** Raymond 1913

Genus **PLIOMEROPS** Raymond 1905

*Pliomerops* sp.

(Pl. 14, figs. 3-4, 6-7)

DESCRIPTION. Cranium incomplete. Glabella quadrangular, expanding forwards from the occipital ring to midway between the pre-occipital and middle furrows, forwards of this having a domed margin, slightly flattened in the centre. Dorsal furrows deeply impressed. Pre-occipital furrows (1p) commencing at one-third the length of the glabella forwards from the occipital ring, running obliquely inwards and backwards for one-quarter the width of the glabella, at that point turning abruptly to run slightly forwards, finally curving round to point obliquely backwards at their inner tips, which are separated by one-eighth the width of the glabella. Middle furrows (2p) commencing just forwards of two-thirds the length of the glabella, running inwards and backwards to as near the midline as the pre-occipital furrows, the tips of the inner ends of the two pairs of furrows being much closer together than their outer ends. Anterior furrows (3p) located on the anterior margin, half way between the midline and the anterolateral corner of the glabella, faint and short, being little more than indentations of the margin. Rear two pairs of glabellar lobes with independent convexity. Axial furrows of the same depth as the glabellar furrows, curving smoothly into the anterior border furrow. Occipital furrow convex forwards at centre, becoming concave forwards towards the axial furrows. Occipital ring not completely preserved, lengthening (*sag.*) towards the midline. Anterior border strongly arched dorsally over the midline, widest at the midline and at the anterolateral angles of the cephalon. Fixigenae incompletely preserved.

Hypostome shield-shaped, anterior border convex, lateral and posterior borders with a sigmoidal curve ending in a posterior point, slightly wider than long, almost flat. Middle body of same shape. Anterior lobe produced into lateral wings, posterior lobe crescentic, defined by middle furrows commencing just behind the wings, broad and shallow, curving gradually inwards. Anterior border poorly preserved, widest at the anterior wings. Lateral and posterior borders of uniform width except at their anterior ends. All border furrows wide and shallow.

Pygidium with shape of an extremely taut bow, just longer than wide, anterior margin very convex forwards. Convex (*tr.*), the margins deflected ventrally at angles up to 90°, almost flat (*sag.*), but convex (*exsag.*). Axis convex, of five flat-topped (*sag.*) axial rings, tapering backwards, followed by a terminal axial piece one and one half times as long as the rings, parallel sided for half its length and tapering to a point in the posterior half. Pleural portions of five pleural lobes, without a border, each lobe widening to the margin and truncated to produce a smooth lateral and posterior border; the last pair surrounding the axis and separated by a median furrow.

## FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Incomplete cranium (In. 58320) . . . . .	16.5	—
Hypostome (In. 58321) . . . . .	14.5	—
Pygidium (In. 58322) . . . . .	39.0	—
Internal mould and interior of pygidium (In. 58323a-b) . . . . .	—	17.0 (est.)

HORIZON AND LOCALITY. Garn Formation, limestone blocks in breccia beds, Porth Padrig, Mynachdy. N.G.R. 30539279.

DISCUSSION. The above descriptions are of isolated pieces from the limestone blocks, and, assuming they belong together, they are assigned to the genus *Pliomerops* Raymond on the basis of the diagnosis given by Harrington (*in* Moore 1959 : O 440). The anterior border is not denticulate, there is no median indentation of the glabella, and the terminal axial piece is long and enclosed. The cranium resembles that of *P. canadensis* (Billings) illustrated in the Treatise (Moore 1959 : fig. 345, 2b) but the pygidia do not. As far as can be seen, most of the described species of *Pliomerops* have short terminal axial pieces and usually a denticulate margin, though the diagnosis in the Treatise (Moore 1959 : O 440) states that the terminal axial piece is long. Reed (1906 : 153, Plate XIX, fig. 16) figures a pygidium very like this as *Pliomera* sp.

B. N. Cooper (1953) has described a pliomereid from Virginia, *Pliomerella americana*, which is somewhat similar to the Anglesey specimens. The pygidium appears to be identical, to judge from Pl. 10, fig. 4 of his paper. This is a crushed specimen, but the long axial piece is apparently enveloped by the posterior pleurae. Another pygidium is illustrated in fig. 1 of the same plate, in which the terminal axial piece is quadrate and reaches the posterior margin, though it may be that the posterior part is missing, and the caption states that the specimen is incomplete. Cooper's text does not indicate whether the axial piece is enveloped or not, and the specimen of his Pl. 10, fig. 1 is re-illustrated on p. O 445 of the Treatise (Moore 1959 : fig. 348, 2b) as being in fact complete. The accompanying text in the Treatise (Moore 1959 : O445) states that a pygidium of this sort is diagnostic of *Pliomerella*. The genus was erected by Reed (1941 : 269) for trilobites with two pairs of glabellar furrows 'combined with some characters of *Pliomera*', but he did not describe a pygidium. It is thus probable that *Pliomerella americana* Cooper does not belong to *Pliomerella*, but possibly to *Pliomerops*, though there is no sign in Cooper's figures of the anterior glabellar furrows, nor does he describe them in the text.

Subfamily **PLACOPARIINAE** Hupé 1953

Genus **PLACOPARIA** Hawle & Corda 1847

*Placoparia* sp.

(Pl. 14, fig. 5)

1919 *Placoparia* sp.: Lake in Greenly : 466.

FIGURED SPECIMEN. Dorsal carapace (Af.1319). Length 23.1 mm.

**HORIZON AND LOCALITY.** Shales of the *Gl. teretiusculus* zone, 80 yds. north of the streamlet, on the shore at Porth-y-gwchiaid (Greenly 1919 : 466). N.G.R. 48799160.

**DISCUSSION.** The species *P. zippei* (Boeck) has recently been divided into two species, *P. zippei* and *P. barrandei* Prantl & Šnajdr, differing in a number of small features, including the glabellar shape, details of the glabellar and ocular furrows, and the development of vincular notches (Whittard 1966 : 283-284). *P. barrandei* itself is a synonym of *P. cambriensis* Hicks (1875 : 186, pl. 9, figs. 1-2) (Dr. W. T. Dean, personal communication).

The Anglesey specimen belongs more probably to *P. cambriensis*, as the glabella is quadrate rather than trapezoidal in outline, though the evidence of the other features is equivocal, probably due to crushing of the specimen.

Family **CALYMENIDAE** Burmeister 1843

Subfamily **CALYMENINAE** Burmeister 1843

*Calymenid* undet.

(Pl. 14, figs. 8-9, 12-13)

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Hypostome (In. 58324) . . . . .	6.7	5.6
Pygidium (In. 58325) . . . . .	9.3	11.5

**HORIZON AND LOCALITY.** Garn Formation, limestone blocks in breccia bed, Porth Padrig, Mynachdy. N.G.R. 30539279.

**DISCUSSION.** The material found consists of one complete pygidium, and one complete and one incomplete hypostome. It is assumed that they all belong to one species.

The pygidium is oval in outline, and strongly convex. The axis gradually tapers backwards, not reaching the posterior border, with six well defined axial rings, a terminal piece and an articulating half ring. The pleural portions show deep pleural furrows with much shallower interpleural furrows, extending to the margin but becoming much fainter on the border. The border is marked by faint depressions running from the tip of the axis to the anterior margins. There are well defined and almost vertically deflected articulating facets, with the foremost pleural groove extending onto them. In posterior view the lateral and posterior margins show a strongly marked arch across the midline. The entire surface, except for the articulating facets and the furrows, is finely tuberculate.

The hypostome is longer than wide, rectangular in outline. The middle body is parallel-sided, with faint diagonal middle furrows dividing off a crescentic posterior lobe, convex longitudinally and sharply convex transversely, without a raised central portion to the anterior lobe. The anterior border is flexed ventrally, continuous with large anterior wings. The lateral borders have a wide gently curved notch extending from the anterior wings to opposite the anterior end of the posterior lobe. The lateral and posterior borders behind this are wide and flat, produced



into points almost one-third of the length of the hypostome, separated by a deep median notch extending to the end of the middle body. The tips of the points and the notch are all sharp, each with an angle of about 50°.

Subdivision of the Calymeninae is based mainly on cephalic characters, so it is not possible to give a generic designation. The upper Ordovician calymenid species have been assigned to five different genera by Shirley (1936 : 400), and of these *Platycalymene*, *Gravicalymene* and *Flexicalymene* agree in their pygidial characters. *Flexicalymene* is the closest in character, and the pygidium described and figured by Shirley (1936 : 406, pl. 29, fig. 7) looks similar, though it is more angular in outline.

Family **HOMALONOTIDAE** Chapman 1890

Subfamily **EOHOMALONOTINAE** Hupé 1953

Genus *NESEURETUS* Hicks 1872

*Neseuretus monensis* (Shirley)

(Pl. 14, figs. 11, 16)

1919 *Calymene parvifrons* Salter; *Lake in Greenly* : 442, 446.

1919 *Calymene tristani* Brongniart; *Lake in Greenly* : 442.

1936 *Synhomalonotus monensis* Shirley : 401.

FIGURED SPECIMENS (measurements in mm.)

	Length	Width
Internal and external moulds of pygidium (In. 58326a-b)	16.9	21.0 (est.)
Internal mould of pygidium (In. 58327)		distorted

HORIZON AND LOCALITY. Carmel Formation, sandstones; In. 58326a-b from 440 yds. north of Ty-hen, Treiorwerth, N.G.R. 35767891; In. 58327 from 120 yds. north-west of Chwaen-bach, Llanerchymedd, N.G.R. 39468378.

DISCUSSION. Shirley described this species from specimens in Greenly's collection (G.S.M. Af. 930-2). The thorax, librigenae and pygidium were not represented in the collection, so only the cranidium was described. Pygidia have been found from the same horizon, and give additional information on the species. The specimen from Chwaen-bach is distorted, and the description is based on that from near Ty-hen (In. 58326).

The pygidium is broader than long, roughly elliptical but with the anterior margin more strongly curved than the borders. The axis bears an articulating half ring and furrow. The axis is funnel-shaped, the tapering portion containing at least six rings, followed by an almost cylindrical portion terminating in a rounded end not quite reaching the posterior margin. The pleural lobes are gently convex, and bear six rounded unfurrowed pleurae, separated by well marked interpleural furrows. The border is sharply rounded, but the form of the doublure is unknown. The pygidium from Chwaen-bach shows pleural furrows which may be the result of crushing.



Family **LICHIDAE** Hawle & Corda 1847  
 Subfamily **TETRALICHINAE** Phleger 1936  
 Genus **AMPHILICHAS** Raymond 1905

*Amphilichas* sp. (1)

(Pl. 14, figs. 10, 14-15, 17)

**DESCRIPTION.** Cranium roughly pentagonal, strongly bent down at the anterior and posterior lateral corners. Glabella rounded, axe-shaped, as broad as long, strongly convex, overhanging in front. Frontero-median lobe prominent, expanded in front to more than twice its basal width; anteriorly strongly convex; anterior lateral angles rounded; posteriorly parallel sided and less convex. First lateral (longitudinal) furrows run inwards towards centre of lobe, curving steadily round to become parallel and meet the occipital furrow at right angles. Lateral lobes gently convex, a little less elevated than the median lobe; bluntly pointed in front, strongly bent down with the antero-median lobe; posterolateral angles extend considerably further back than the median lobe. Axial furrows as strong as longitudinal furrows, posteriorly parallel to them, diverging slightly in front of the eyes. Occipital furrow straight and horizontal behind median lobe, directed obliquely backwards behind the lateral lobes, and less obliquely behind the fixigenae. Occipital ring not completely preserved but possibly widest behind the median lobe. Fixigenae posteriorly equal in width to the lateral lobes, narrowing to less than half that width opposite the eye; expanding in front of the eye; expanding in front of the eye but not completely preserved. Course of facial suture only seen round eye, running outwards behind it. Palpebral lobe semicircular, convex inwards; its length is one-fifth that of the glabella and its posterior end level with the occipital furrow. Entire cranium, except for the furrows, covered with tubercles of varying size, irregularly placed.

Hypostome oval in outline, broader than long. Posterior border broad, posterior margin indented. Middle body circumscribed. Posterior lateral lobes well defined by median furrows running inwards slightly posteriorly with short bifurcations at their inner ends. Lateral borders broad, with short triangular wings opposite the posterior border furrow. Anterior border appears to be lacking. Anterior part of middle body pitted; anastomosing ridges or terrace lines on remainder of surface.

**FIGURED SPECIMENS** (measurements in mm.)

	Length	Width
Incomplete cranium (In.58328) . . . . .	14.9	—
Hypostome (In.58329) . . . . .	5.8 (sag.)	7.9

**HORIZON AND LOCALITY.** Garn Formation, limestone blocks in breccia beds, Porth Padrig, Mynachdy. N.G.R. 30539279.

**DISCUSSION.** No thoracic segments have been found, and the only remains of pygidia so far found are too incomplete to describe; they only show the typical development of tubercles. The cranium shows similarities to *A. wahlenbergi*

Warburg from the *Leptaena* Limestone in Dalarne, and also to *Lichas* (*Amphilichas*) *hibernicus* (Portlock) (Reed 1906 : 106, pl. 15, fi. 1 non 2-3).

*Amphilichas* sp. (2)

(Pl. 14, figs. 18-19)

DESCRIPTION. Outline possibly semicircular, weakly convex both longitudinally and transversely, probably crushed. Frontero-median lobe convex, expanding forwards to over twice its posterior width; the longitudinal furrows being parallel posteriorly and curving outwards to diverge at more than  $90^\circ$  where they meet the axial furrow, not reaching the occipital furrow but ending in a pit. Tricomposite lobe widening very slightly forwards, at its posterior end the same width as the median lobe posteriorly; axial furrows concentric with the longitudinal furrows but with smaller radius of curvature. Fixigena incomplete, narrow, posterior to the eye less than half the width of the tricomposite lobe, cut into by the eye lobe, which is one-fifth the length of the cranium. Only a fragment of the occipital ring preserved. Surface evenly pitted.

FIGURED SPECIMEN (measurements in mm.)

	Length	Width
Incomplete external mould of cranium (Af. 3000)	17 app.	—

HORIZON AND LOCALITY. Tandinas shales, by the track 50 yds. west of Tandinas quarry, Careg-onen. N.G.R. 58248187.

DISCUSSION. There appear to be no basal lobes, so that the specimen belongs to *Amphilichas*, although there is little to compare closely with *Amphilichas* sp. (1) from Porth Padrig.

Family uncertain

Genus *MONELLA* nov.

DIAGNOSIS. Genus similar to *Glossopleura* Poulsen, but differing in having more strongly marked glabellar furrows, the anterior ends of the palpebral lobes not touching the glabella, and eleven (compared with eight) thoracic segments.

TYPE SPECIES. *Monella perplexa* sp. nov. from the Carmel Formation.

DISCUSSION. The specimens assigned to the new genus were referred by Lake (*in* Greenly 1919) to *Ogygia*, but certainly do not belong to the suborder *Asaphina*. The thorax consists of eleven segments and the glabella is distinctly furrowed, a combination of characters that is quite different from any contemporary trilobites, but generally characteristic of the Order *Corynexochida*, though the rostral plate and hypostome have yet to be found. The glabella is clavate and reaches the anterior margin, the eyes are large and semicircular, with prominent palpebral lobes, though eye ridges are not present. The closest genera are found in the family Dolichometopidae, of the order *Corynexochida*. *Athabaskiella* has a similar cephalon, but a smaller pygidium with only four segments differentiated in the pleural regions

and fewer in the axis. *Bathyriscus* has smaller eyes which are not semicircular, and a very narrow border to the pygidium. *Dolichometopsis* has a pygidium without a border and with a terminal indentation, and *Glossopleura* has very faint glabellar furrows, only eight thoracic segments, and differs in the position of the palpebral lobes.

*Monella perplexa* gen. et sp. nov.

(Pl. II, figs. 15-21)

1919 *Ogygia* sp. (*pars*); Lake in Greenly : 446.

DIAGNOSIS. As for genus.

DESCRIPTION. Outline ovate, cephalon larger than pygidium. Cephalon semicircular, over twice as broad as long. Glabella clavate, between one and one-quarter and two times as long as broad, convex transversely and slightly convex longitudinally; glabellar lobes with independent convexity; three pairs of glabellar furrows, one quarter the width of the glabella, shallow at their abaxial ends; posterior pair (1p) at one quarter the length of the glabella forwards, inclined obliquely backwards and becoming shallower and wider at their adaxial ends; 2p inclined slightly backwards, situated just forward of half the length of the glabella; 3p transverse or slightly inclined forwards, nearer 2p than the front of the glabella; anterior margin of glabella convex forwards, lateral margins and the distinct axial furrows evenly and gently convex adaxially, with well marked fossulae midway between 3p and the front of the glabella. Occipital ring continues the convexity of the glabella, one sixth its length (*sag.*); occipital furrow distinct. Fixigenae smaller than the glabella or the librigenae. Palpebral lobes semicircular, posterior extremities just anterior to the base of the glabella; anterior extremities between the 2p and 3p furrows, separated from the axial furrows at each end by one-third the width of the glabella. No preglabellar field. Anterior border furrow narrow, anterior border with a vertically deflected margin. Facial sutures opisthoparian, posterior branches diverging backwards to cut the posterior margin midway between the axial furrow and the genal spine; anterior branches run directly forwards from the eye to the margin. Librigenae convex, genal spine equal in length to the glabella. Posterior border straight to the facial suture, then curving abaxially from it evenly round to the genal spine; posterior and lateral furrows well defined, posterior border half the width of the occipital ring (*sag.*); the lateral border with a vertical deflection. Doublure wide.

Hypostome and rostral plate unknown.

Thorax of eleven segments. Axis cylindrical, tapering slightly, equal in width to the pleural regions, articulating half-rings equal in length (*sag.*) to the axial rings; interpleural furrows curving slightly forwards towards the axial furrows. Pleural regions flat adaxially, deflected ventrally in their abaxial regions; pleural furrows transverse, dying out between fulcra and extremities; short, backwardly directed pleural spines formed by the extremities of the pleurae being tapered.

Anterior three(?) segments narrower (*tr.*) than the rest and undeflected at their ends.

Pygidium semicircular. Axis convex, tapering to a point and extending onto the border but not reaching the posterior margin, eight or possibly more axial rings present. Pleural lobes gently convex with pleural furrows only. Border broad, concave, doublure equal to it in width.

TYPE SPECIMENS (measurements in mm.)

		Length	Width
HOLOTYPE.	Counterpart moulds of complete dorsal carapace (Af. 827-8)	—	13.7
PARATYPES.	Internal mould of cranidium (Af. 834)	—	—
	Internal mould of cranidium (Af. 836)	—	—
	Internal mould of pygidium (Af. 839)	—	—

OTHER FIGURED SPECIMEN

	External mould of incomplete dorsal carapace (In. 58290)	—	—
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TYPE HORIZON AND LOCALITY. Carmel Formation, sandstones in old quarry (now filled in), 400 yds. north-north-west of Bryn Gollen Uchaf, Llanerchymedd. N.G.R. 40508425. Other figured specimen from same horizon, on the escarpment 50 yds. north-east of Prys-owain-bach, Carmel. N.G.R. 38878283.

DISCUSSION. The generic position of *M. perplexa* has already been discussed, and it is at present the only species known of the genus.

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